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Potential Vertical Rise of Lime-Treated Expansive Clays Using Centrifuge Technology

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Potential Vertical Rise of Lime-Treated Expansive Clays Using Centrifuge Technology

by

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Thesis

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Abstract

Potential Vertical Rise of Lime-Treated Expansive Clays Using Centrifuge Technology

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Expansive soils are prevalent throughout Central Texas and can cause extensive damage to pavements and other lightweight transportation projects. Methods of directly quantifying soil swell potential are often prohibitively time-consuming, and indirect methods that correlate swell to soil index properties are often based on limited empirical data and ignore variances in soil mineralogy that can significantly affect swell.

Soil stabilization or modification, using additives like Portland cement or lime, is often utilized to mitigate the effects of expansive soil. In particular, the Texas Department of Transportation (TxDOT) recommends lime treatment for highly plastic soils below many transportation projects. However, many common design procedures do not directly measure the swell potential of the lime-treated soils and rather rely on methods like the Eades-Grim pH test to determine dosage. Additionally, design procedures do not often include a method for determining project-specific treatment depths. This research seeks to develop a procedure for directly quantifying the swell of lime-treated soils such that a project-specific treatment depth and dosage may be prescribed.

Centrifuge tests performed on Eagle Ford clay were used to assess the effects of the testing procedure on swell results. It was determined that mellowing lime-treated soil samples did not significantly affect their swell potential but did increase soil workability. Additionally, curing of lime-treated soil samples decreased swell for samples treated with 4% by dry mass hydrated lime after curing for at least 6 weeks, but curing for any time did not decrease swell for samples treated with 2% hydrated lime. It was concluded that lime-treated swell testing could be optimally performed on uncured samples that were allowed to mellow for 12-24 hours to maximize workability.

The reduced testing procedure for directly calculating an untreated and lime-treated soil potential vertical rise (PVR) recommends obtaining 3 data points across a representative range of stresses for each distinct layer of untreated soil in a given stratum, which is fit to a semi-log linear curve. One data point is used for each lime dosage to be tested, and the approximation of a unique soil swell pressure is used to produce a semi-log linear stress-swell curve from each of these points. The area under each curve for the stress range in question is then used to calculate the PVR of a soil profile. PVR analyses on two sites from San Antonio in Bexar County, Texas show that the assumption of log-linear stress-swell curves and the approximation of a constant swell pressure return PVR calculations that are similar to those calculated from stress-swell curves that require more parameters and more data points to propagate.

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1. INTRODUCTION

1.1. Motivation

Expansive soils are generally defined as soils that tend to change volume significantly due to moisture variations – either in swelling with an increase in moisture or shrinking with a decrease in moisture. Moisture fluctuations are often uneven across a soil stratum, resulting in differential movement in a stretch of expansive soil. These differential movements can cause extensive damage to the above structures, particularly in relatively lightweight structures like pavements. Constructing pavement systems over expansive clays can lead to cracking, rutting, and general increased roughness, all of which may allow the soil to become more susceptible to moisture infiltration and otherwise affect its design life. Jones and Jefferson (2012) estimate that damage to US buildings and infrastructure due to expansive soils exceed $15 billion annually. Expansive soils are present throughout the world and are especially prevalent in Central and East Texas, as shown in Figure 1-1. Most of the population of Texas reside in the bands containing high frequencies of expansive soil (Dallas, Fort Worth, Austin, and San Antonio), meaning that a large portion of Texas residents may be affected by issues caused by expansive soils.

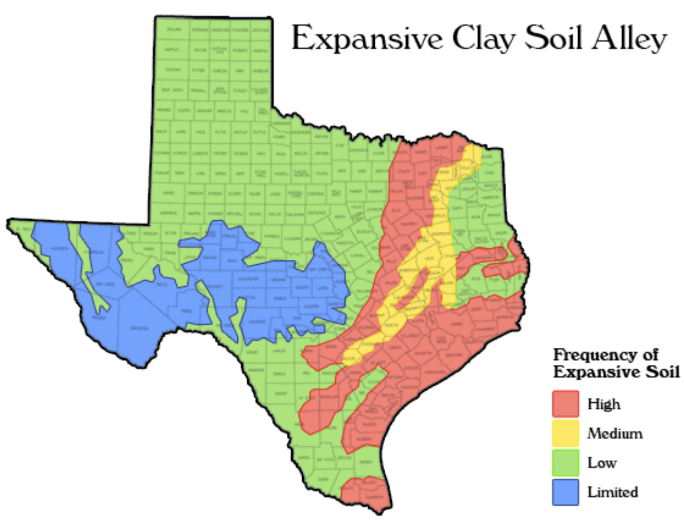


Figure 1-1. Expansive Soil Distribution in Texas

Due to its prevalence, a significant volume of research has been conducted on the quantification and treatment of expansive soils. Methods of quantifying the swell potential of expansive soils include directly measuring the change in sample volume after inundation (direct method) or calculating a swell potential based on index properties of the soil (indirect method). The most common direct method is the free swell test, which is detailed in ASTM D4546. This test involves placing a compacted soil sample in a consolidation frame and measuring the change in height after inundation while under an applied stress. While effective, these tests are rather time-consuming – often taking weeks or even months to run to completion – and thus are not often used outside of research purposes. Instead, indirect methods are often utilized in practical applications, e.g. the approach documented in Tex-124-E that is used by the Texas Department of Transportation (TxDOT). This method uses the plasticity index and initial moisture content of a given soil to estimate its swelling potential based on empirical comparisons of a number of Central Texas expansive soils. Although this method is simple to implement, its empirical nature allows for significant variability depending on soil mineralogy and other initial conditions.

To help address the issues arising from these two methods, a new testing method using centrifuge technology was developed at The University of Texas at Austin. A centrifuge, able to test several samples at once, spins at a prescribed speed, imparting an increased head gradient on the sample which allows for accelerated water infiltration (tests are often run to completion within 1 to 3 days). The height of each sample is measured continuously via an in-flight data acquisition system, allowing for direct measurement of swell potential. Additionally, variation of centrifuge speed or variation of overburden weight on soil samples allows for a wide range of effective stresses to be tested, thus a full soil-specific stress-swell curve can be created fairly rapidly. Several studies have been conducted on the centrifuge method that confirm its accuracy and efficiency in quantifying swell potential (Zornberg et al 2008; Plaisted 2009; Kuhn 2010; Zornberg et al 2013; Armstrong 2014). The centrifuge procedure can then be used to directly calculate the potential vertical rise (PVR) of a soil profile, or the amount by which a soil profile is expected to swell vertically when wetted (Snyder 2015; Zornberg et al 2017).

To mitigate the effects of expansive soil, methods of soil stabilization or treatment have been widely researched, with options including soil replacement, geosynthetic installation, and the addition of chemical stabilizers like lime or Portland cement. The use of lime is especially common in Texas, where large quantities of limestone are available, and is recommended by TxDOT for use in high plasticity soils to reduce their swell potential. To determine the amount of lime required for soil stabilization, a method called the Eades-Grim Test is commonly used (ASTM D6276; Tex-121-E). In this method, a series of soil slurries are mixed with increasing percentages of lime, and the pH of each slurry is measured. The prescribed lime percentage corresponds to the lowest amount of lime that allows the slurry to reach a pH of 12.4, at which point the pozzolanic reactions between clay particles and lime may fully occur. This method is fairly simple to perform; however, this method does not account for the effects of short-term soil modification. Soil stabilization with lime requires the cementation reactions that occur in the long term, but these reactions may require more lime than is necessary to decrease the soil's swell potential. Additionally, in cases like pavement design where the stresses acting on the subgrade are relatively low, the increase in strength due to pozzolanic reactions are likely not necessary. In either case, the recommended depth of treatment cannot be directly calculated, which can lead to inaccuracies in subgrade design.

Some recent studies have been conducted on directly measuring the swell potential of lime-treated expansive soils both in free swell setups and in using centrifuge technology (Belchior 2016). Centrifuge testing has shown to be an effective means of directly measuring the reduction in swell potential of a lime-treated soil. The main purposes of this research are to assess the characteristics of soil-specific lime-treated stress-swell curves using centrifuge technology and to develop a method of directly calculating the PVR of a lime-treated soil profile that is both accurate and efficient. This method could then be utilized in pavement subgrade design to accurately determine a depth and level of treatment using a minimum number of tests while maintaining the integrity of the method.

1.2. Objectives and Scope of Research

A key objective of this research is to develop a reduced testing and analysis procedure to determine the potential vertical rise (PVR) of an expansive subgrade and determine the required depth of treatment with hydrated lime to reduce the PVR to a prescribed level. This testing procedure utilizes centrifuge technology to directly measure swell potential, in contrast to the empirically-based PVR calculation method that is currently used by the Texas Department of Transportation. A second objective is to determine optimized baseline test preparation conditions for centrifuge testing of lime-treated expansive clays and to observe sources of variance within the centrifuge testing procedure. This objective is assessed using centrifuge tests performed on Eagle Ford shale, a highly expansive clay found in Central Texas. A third objective is to compare the

PVR and required depths of treatment from the reduced analysis procedure with the calculated PVR and required depth of treatment with an analysis procedure previously documented by Snyder 2015. This comparison uses soil data from two soil borings in San Antonio.

1.3. Overview of Thesis

This thesis is divided into eight chapters and an appendix. Chapter 1 presents the motivation, objectives, and overview of the thesis. Chapter 2 presents background information on expansive soils and lime treatment, along with previous research on centrifuge testing of expansive clays. Chapter 3 compares different methods of calculating potential vertical rise (PVR) using indirect and direct measurements of swell. Chapter 4 discusses sources of variation or error within the centrifuge test preparation and testing procedure aside from compaction characteristics. Chapter 5 presents the results of centrifuge tests on untreated and lime-treated Eagle Ford clay and details the recommended soil preparation procedures for testing lime-treated samples. Chapter 6 details the recommended testing and analysis procedure for optimizing the design of a lime-treated expansive subgrade. Chapter 7 uses this analysis procedure to provide examples from two soil borings obtained from field visits. Finally, Chapter 8 presents main conclusions from the research study and offers recommendations for further research and testing of lime-treated expansive clays. The appendix includes results from the discussed centrifuge tests and free swell tests.

2. BACKGROUND INFORMATION

2.1. Expansive Soils

Expansive soils are often characterized by a high plasticity index and the presence of smectites or montmorillonites. Smectites are a group of minerals that are comprised of one octahedral alumina (or gibbsite) sheet between two tetrahedral silica sheets, with montmorillonite being the main mineral in the group. These structures are connected through van der Waals forces between the outer silica sheets of each individual structure. Because van der Waals forces are one of the weakest types of intermolecular forces, the introduction of water can break through these bonds much more easily than through, for example, hydrogen bonds or ionic bonds that hold together other types of clay minerals, thus causing expansion of the soil fabric.

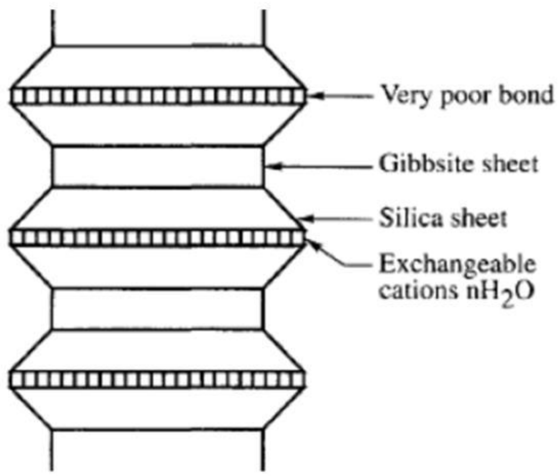


Figure 2-1. Structure of Smectites

2.2. Direct Measurements of Swell

The most popular method of measuring soil swell potential is through the use of a 1-dimensional oedometer per ASTM D4546, also called the "Free Swell Test". The testing equipment is the same as that used in a consolidation test; however, the sample is not inundated before the test begins. A sample is allowed to compress under a prescribed load, and then the sample is inundated while wetting-induced strains are measured. The sample height is measured at regular intervals until the end of primary swell is reached, which generally takes 24-72 hours. ASTM D4546 details three different methods of performing the test.

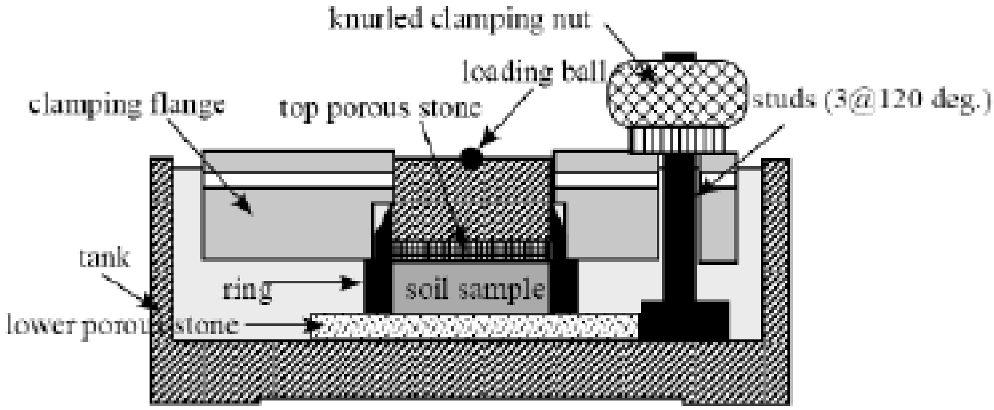


Figure 2-2. Diagram of Consolidation Cell used in ASTM D4546 (Olson 2009)

Test Method A is referred to as wetting-after-loading tests and is to be performed on a series of 4 or more identically compacted reconstituted samples. Each sample is compacted and placed in a consolidation cell, where it is placed under a 1 kPa seating load. Afterwards, each sample is to be placed under a different compression load, such that the samples are tested under the required range of stresses. Samples are then inundated, and deformations are read at intervals of 0.5 min, 1 min, 2 min, 4 min, 8 min, 15 min, 30 min, 1 h, 2 h, 4 h, 8 h, and 24 h until the end of primary swell has been reached. An example of this time-deformation data is shown in Figure 2-3. The end of primary swell is defined as the inflection point between the "primary swell" and "secondary swell" portions of the curve.

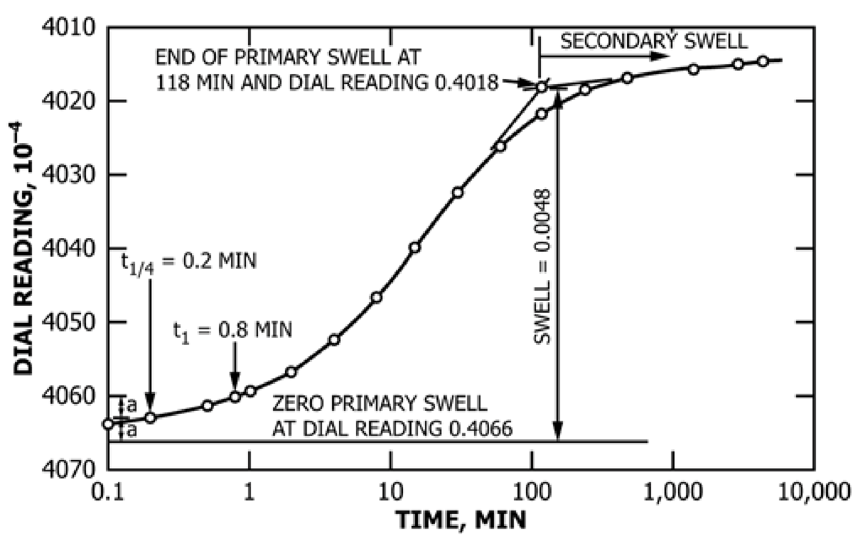


Figure 2-3. Example Time-Swell Curve from ASTM D4546 Method A

This process is repeated for each of the samples, and the stress-swell data can be plotted as shown in Figure 2-4. This method can also be used to determine the “swell pressure” of the soil, or the stress at which point the soil does not swell. This would be determined by interpolating or extrapolating the obtained stress-swell data to find the stress at which the horizontal axis is crossed.

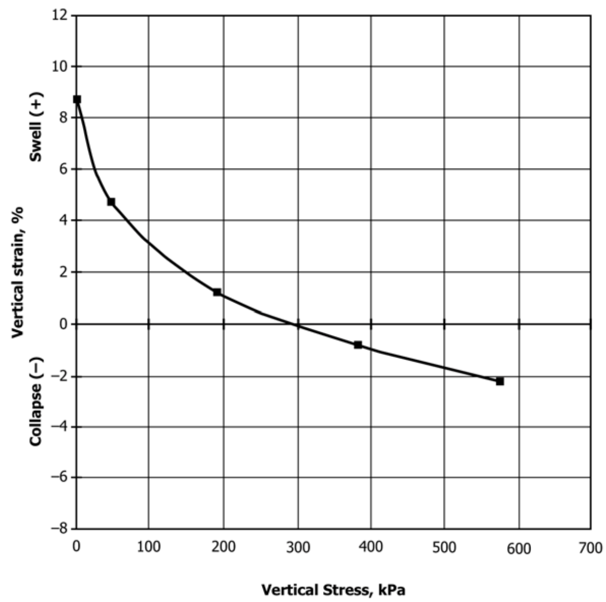


Figure 2-4. Example Stress-Swell Curve from ASTM Test Method A

Test Method B is referred to as the single-point-wetting-after-loading test and is generally used for measuring the wetting-induced swell on intact soil samples. Samples are tested under an effective stress to match in-situ field conditions, such that the test provides information on the amount of swell to be expected from a soil layer at a given depth if the soil is fully wetted from its initial moisture condition. An example of the stress-swell data procured from Method B is shown in Figure 2-5.

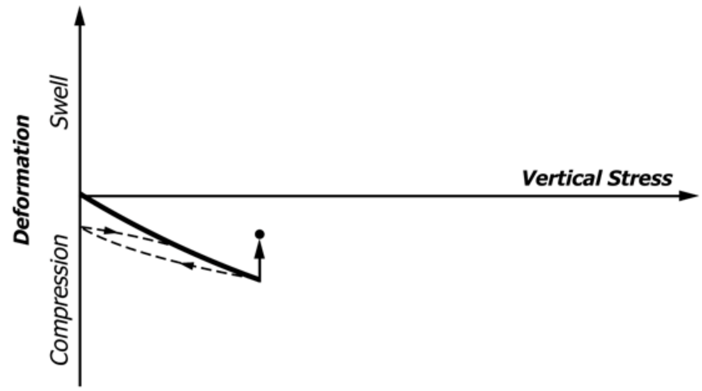


Figure 2-5. Example Stress-Swell Curve from ASTM Test Method B

Test Method C is referred to as the loading-after-wetting test and can be performed on either reconstituted or intact samples. In this method, the sample is allowed to fully swell under a prescribed load, per Method A or Method B. After this, additional load is added incrementally to the sample while strains are measured – effectively performing a consolidation test on a sample that has undergone wetting-induced swell. Using this method, the swell pressure of the soil may be determined using one test, rather than 4-5 tests running in parallel for Method A. Figure 2-6 shows example results from Test Method C. The sample is allowed to swell after an initial loading, and then the sample is incrementally loaded until returning to its initial height. The stress at which the sample is consolidated back to its initial height is determined to be the swell pressure.

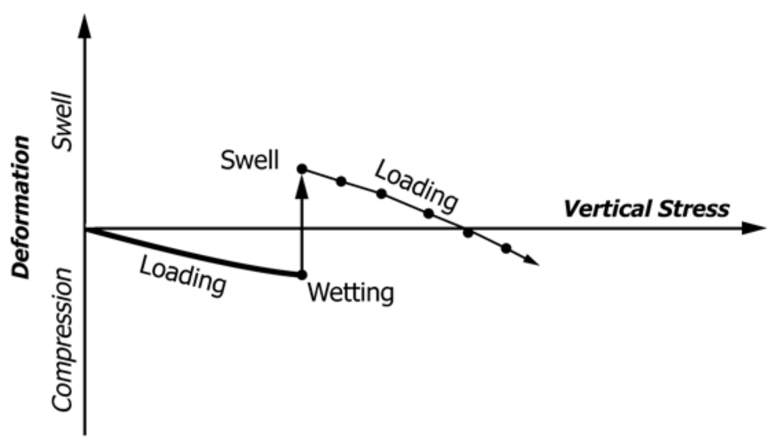


Figure 2-6. Example Stress-Swell Curve from ASTM Test Method C

Using a 1-D oedometer setup, primary swell may be reached within a few days, but it is also necessary to have a significant amount of secondary swell to properly determine the end of primary swell in a soil sample. With this taken into account, free swell tests can sometimes take days to weeks, which is often unsuitable for testing outside of research facilities.

2.3. Lime Treatment of Expansive Soil

One of the most widely used methods of mitigating issues from expansive clay is through soil stabilization by the addition of lime. Two types of lime are often used in soil stabilization – quicklime (compound CaO) and hydrated lime (quicklime plus water, $Ca(OH)_2$). Each of these produces similar chemical reactions when introduced to the alumina and silica in soil under the presence of water. Both short-term and long-term stages of these reactions occur, and both are taken into account in the Texas Department of Transportation (TxDOT) design method of lime-stabilized expansive soils.

Figure 2-7. Increased Friability in Lime-Treated Clay

There are three types of short-term reactions that occur – cation exchange, flocculation, and carbonation. In cation exchange, the Ca^{2+} ions from lime replace the cations currently between smectite sheets and subsequently bond the sheets more strongly together and decrease the thickness of the diffused water layer between silica sheets. Additionally, as the diffused water layer thins, particles become closer together and the soil becomes more *flocculated*, resulting in larger particles and larger void ratios, which subsequently increases the optimum water content of the soil and decreases its maximum dry density. A visual representation of this flocculation effect can be seen in Figure 2-7. The soil on the left-hand side of the image is untreated high plasticity clayey soil, and the soil on the right-hand side is the same soil after being treated with lime. One can easily see the effect of lime treatment – the right-hand soil particles have coagulated into flocs rather than create a more uniform and soft clay subgrade. It is also worth noting that although the treated soil has a higher optimum water content, the soil 'looks' drier than the untreated clay. This is because the soil-lime reactions require a sizeable amount of water to occur.

A secondary effect of this reaction is an increase in OH^- ions in solution, which leads to an increase in pH of the system (which is often used as a design method in lime-stabilized soils). As pH reaches 12.4, the clay particles begin to break down and the silica and alumina become soluble and subsequently react with calcium ions to produce cementitious materials: calcium silicate hydrate and calcium aluminate hydrates. These reactions are referred to as pozzolanic reactions and often require long periods to occur fully.

In addition to lime percentages, two important determinations of the stabilization process are that of mellowing time and curing time. Mellowing is defined as the period between soil-lime mixing and compaction, whereas curing is defined as the period after final compaction before further site construction.

A mellowing time is usually included to allow sufficient time for the soil, lime, and water to mix and produce a more homogenous and friable material that is then much easier to mix and compact for construction. However, research is split on whether or not mellowing time has an adverse effect on the compressive strength of the soil-lime mixture. In general, it is seen that mellowing times decrease the compressive strength of soils but may or may not increase the swell potential of these soils. Research conducted by Belchior, 2016, observed the effects of both curing time and mellowing time on the strength and swell properties of soil-lime mixtures. It was found that a longer mellowing period may increase the swell potential of expansive soils and may be attributed to loss of lime through carbonation and through air voids created during mellowing. Additionally, an extended mellowing period (7 days) produced lower compressive strengths than periods of no mellowing time; again, this could be attributed to increased air voids and loss of lime through carbonation.

However, the procedures documented by TxDOT tend to include a mellowing time in their test procedure in addition to construction specifications, so any sizeable decreases in compressive strength are likely taken into account. Additionally, an increased mellowing period may be beneficial to treated soils with a high sulfate content to allow the detrimental reactions to proceed before compaction and strength testing.

Curing, on the other hand, is generally performed to allow some of the pozzolanic reactions to occur and have the soil begin to strengthen before final construction occurs. Generally, an increase in curing time significantly decreases the expansive soil swell potential and increases its compressive strength. Research conducted by Belchior, 2016, and a number of others have noted that curing significantly increases soil strength and decreases swell, to a point. After a curing period of approximately 7 days, there is not a significant benefit in longer curing periods to the swell potential or compressive strength.

2.4. Centrifuge Testing of Expansive Clays

Due to the time-consuming nature of free swell tests, the use of a geotechnical centrifuge to accelerate swell testing has proved to be very useful. There are two main factors driving swell in these tests: a suction gradient and an elevation gradient. Increasing gravitation on the samples increases the elevation gradient acting on the soil, which expedites the process of reaching end of primary swell in addition to decreasing the amount of observed secondary swell.

The use of centrifuge technology to test expansive soils was piloted by Frydman and Weisberg, 1991, who performed tests on a highly plastic clay found in Israel called Mizra clay. The soil was compacted in 20-mm layers into a column of 112 mm diameter and 300 mm height, with a freely draining base and a constant height of water ponded on top. To monitor swelling and the advancement of the wetting front in the soil, 3-mm steel balls and electrical transducers were placed between each compacted layer. Photo analysis on the steel balls were used to determine strains in the soil, and resistance measured from the transducers was used to monitor the wetting front. Additionally, the columns were scanned with gamma ray transmission to obtain moisture content and dry density data. Centrifuge tests were replicated in a 1-D oedometer to directly compare results, which are shown in Figure 2-8.

It was observed that, at low stresses, the centrifuge tests swelled more than the 1-D oedometer tests, while the converse was true at higher stresses. Because it was observed that the swelling calculated by the movement of the steel balls around the column edge was less than that measured in the center of the column via gamma ray scanning, it was concluded that friction between the soil and column wall caused the discrepancies. The research concluded that centrifuge testing is very handy for swelling expansive clays as long as efforts are made to minimize frictional effects.

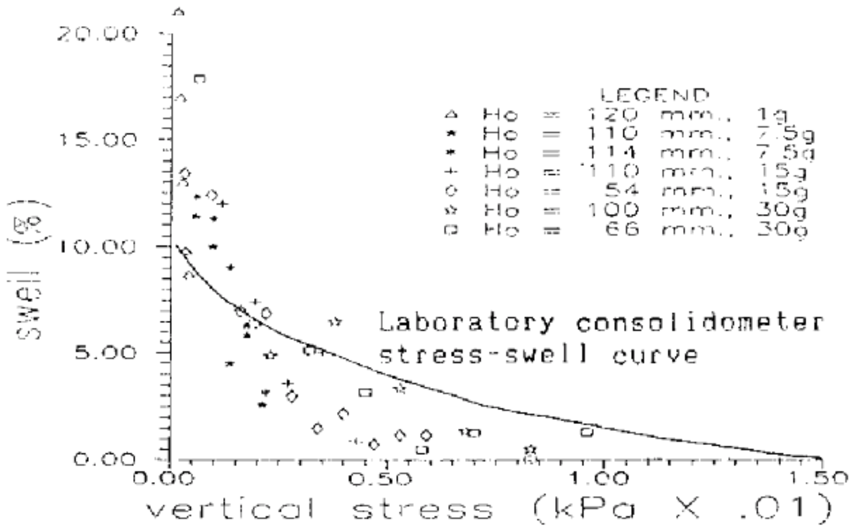


Figure 2-8. Stress-Swell Data (Frydman and Weisberg, 1991)

The centrifuge testing procedure at The University of Texas at Austin was piloted in part by Michael Plaisted, who designed the "single infiltration" permeameter setup used in compacting and testing soil samples in the pilot centrifuge setup. This setup consisted of a top cup, intended to hold the soil sample and ponded water, and a bottom cup which was intended to collect the outflow of water from the sample. Porous discs and filter paper on either side of the soil sample allowed water to flow through the specimen without losing soil and to protect the soil from the applied overburden pressure (applied by metal washers). Figure 2-9 shows a schematic of the single infiltration test setup.

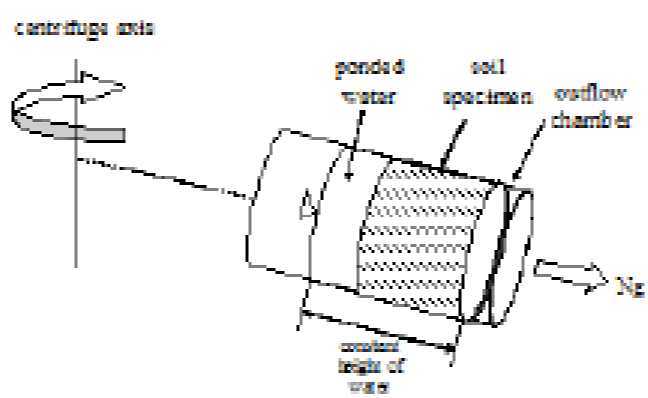


Figure 2-9. Single Infiltration Test Schematic (Plaisted 2009)

Centrifuge tests were performed on Eagle Ford clay, a highly plastic clay formed from weathered shale in Round Rock, Texas. Samples were compacted at the maximum dry density and optimum moisture content as determined by Standard Proctor compaction tests. Periodically throughout the test, the mass of the permeameter cup and outflow chamber and the height of the sample were measured, such that flow and sample height could be monitored. An example of centrifuge time-deformation data is shown in comparison with free-swell time-deformation data in Figure -10. It is noted that the centrifuge tends to over predict swell values as compared to the free swell setup, and the centrifuge method has more scatter. This was determined to be caused by additional swelling that occurs in the centrifuge sample, after being removed and before measurements can be obtained. When samples are removed to take height measurements, the rapid decrease in gravitation effectively unloads the sample temporarily, leading to an increase in strain. Plaisted's research helped to develop a curve fitting relationship for centrifuge-produced stress-swell curves and demonstrated that The University of Texas at Austin had resources available to use the centrifuge to test expansive clay samples.

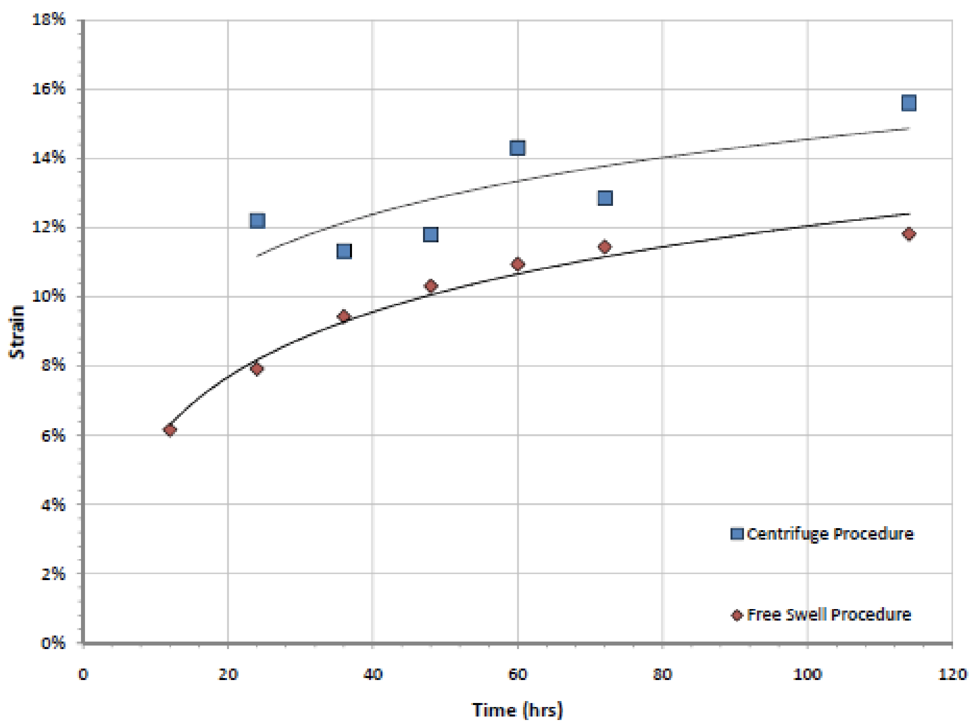


Figure 2-10. Example Centrifuge Data as Compared with Free Swell Data (Plaisted 2009)

Jeffrey Kuhn continued research in centrifuge testing of expansive clays. Again using Eagle Ford, Kuhn performed tests in a custom-built large-scale centrifuge at The University of Texas, using a permeameter cup diagrammed in Figure 2-11.

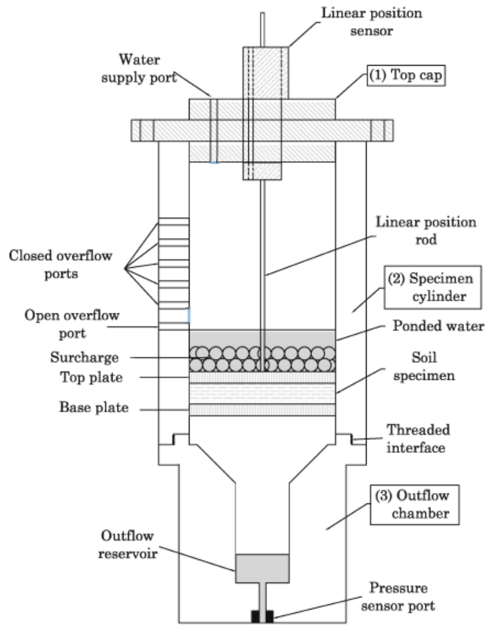


Figure 2-11. Large Centrifuge Permeameter Cup Schematic (Kuhn 2010)

The large-scale centrifuge setup included a linear position sensor such that the height of the sample could be continuously measured without removing the sample from centrifugation. Samples were tested at 3 different g-levels under 2 different scenarios: 1) samples tested with constant water height and surcharge mass, such that g-level was the only variable, and 2) samples tested with water height and surcharge mass such that samples run at different g-levels were all under a constant total stress. Results of this testing program are shown in Figure 2-12. Kuhn's research demonstrated that use of either scenario produces similar results and that the use of linear position sensors to directly measure sample height is very beneficial to centrifuge testing.

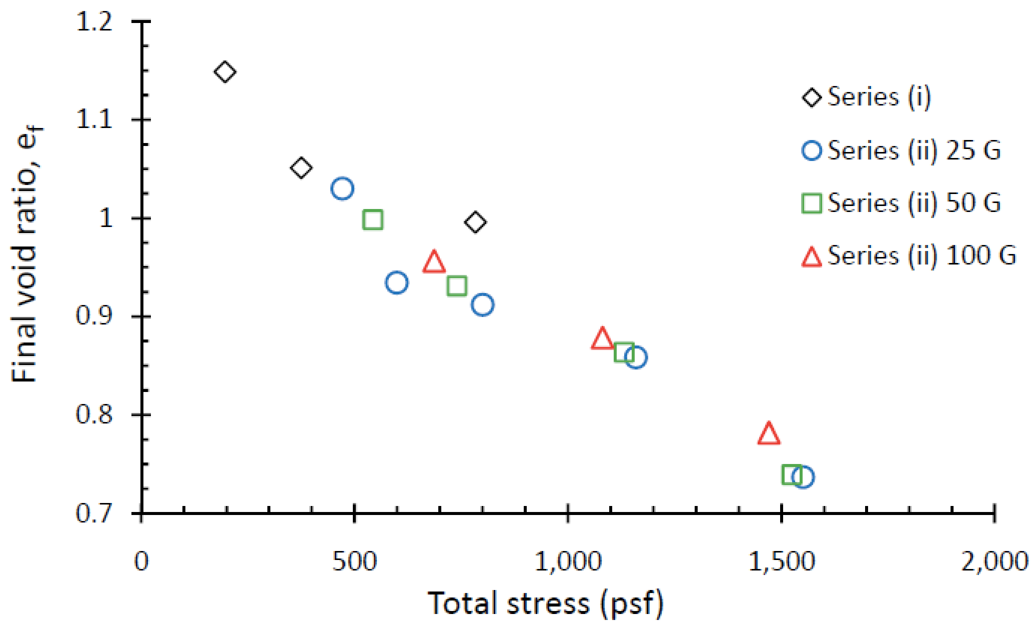


Figure 2-12. Example Stress-Swell Data Obtained Through Large Centrifuge Testing (Kuhn 2010)

The use of linear position sensors (LPS) were then implemented in the original small centrifuge set-up, as researched by Walker, 2012. An in-flight data acquisition system was developed, consisting of a JeeNode Arduino board and receiver, an accelerometer, linear position sensors, and a battery power supply. Figure 2-13 illustrates some of the main components of this system. The power supply is shown in Figure 2-13a and consists of 4-AA batteries. The LPS is shown in Figure 2-13b and is attached to a lid that fits flush with the sample permeameter cups, such that the bottom of the LPS rests on the top of the sample. Figure 2-13c shows the Arduino board with analog to digital converter, which wirelessly sends data to an external Arduino receiver that is plugged into a computer. Figure 2-13d shows the accelerometer that is set up inside the centrifuge to measure g-level throughout the test.

This setup was used to perform swell tests on three expansive soils native to Central Texas: Eagle Ford, Houston Black, and Tan Taylor clays. The testing matrix for these soils sought to evaluate the effect of initial compaction conditions (moisture content and dry density) on the swell potential of the soils. Swell data for Eagle Ford Clay can be seen in Figure 2-14.

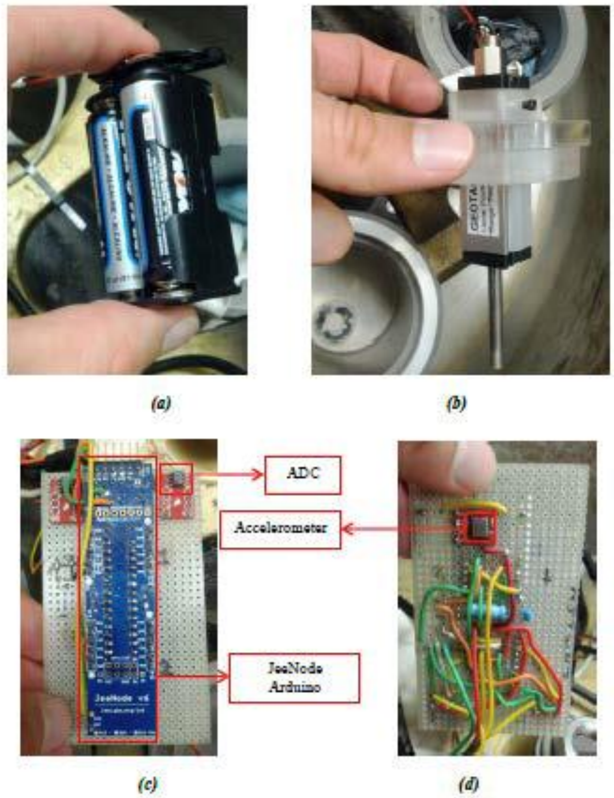


Figure 2-13. Components of Centrifuge Data Acquisition System (Walker 2012)

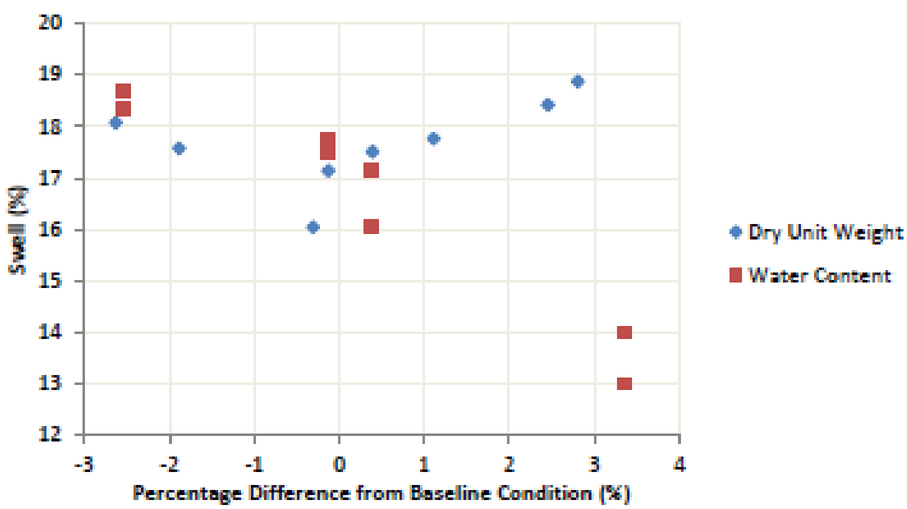


Figure 2-14. Effect of Varying Dry Unit Weight and Initial Moisture Content on Swell for Eagle Ford Clay (Walker 2012)

As can be seen, a strong correlation between increasing compaction moisture content and decreasing swell can be seen, along with a general correlation between increasing dry density and increasing swell. Additionally, the testing program demonstrated that the use of LPS and an in-flight data acquisition system could be successfully implemented as part of the centrifuge methodology.

To further increase the accuracy and reliability of the centrifuge methodology, research performed by Christian Armstrong included the design of a new permeameter cup that more closely matched boundary conditions imposed by that in typical free swell test procedures. Referred to as the double-infiltration setup, the cup allows water to infiltrate the sample from the top and bottom. Two other developments in this test method are: 1) an aluminum ring that can be used to both compact reconstituted samples and to trim intact samples for centrifuge testing, and 2) brass porous discs of varying sizes that replace the combination of acrylic discs and metal washers and allow for testing at lower g-levels to attain the same stress ranges. These test components are shown in Figure 2-15.

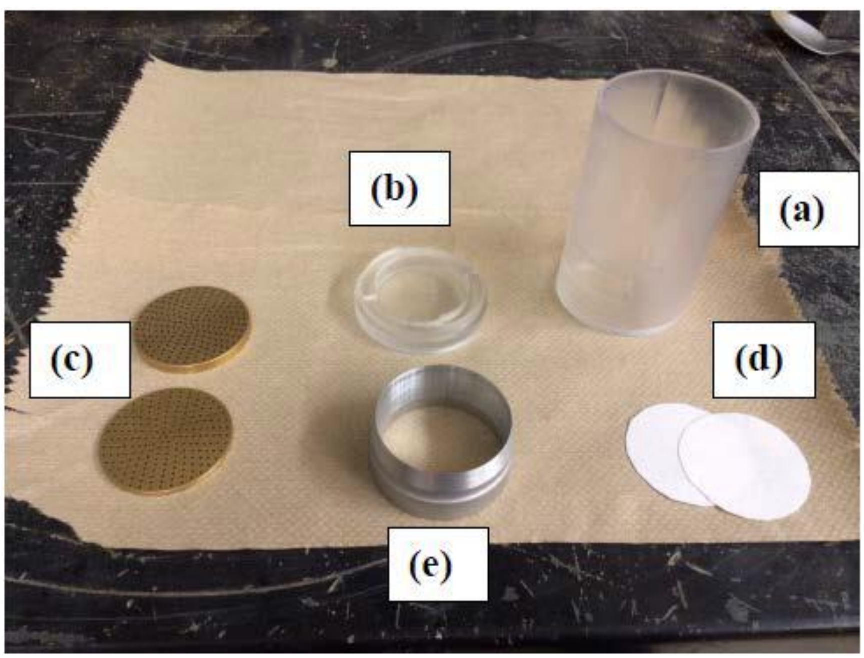


Figure 2-15. Double Infiltration Test Setup: (a) Permeameter Cup, (b) Permeameter Lid, (c) Brass Porous Discs, (d) Filter Paper, (e) Cutting Ring (Armstrong 2014)

Armstrong’s research sought to evaluate the effect of soil fabric on soil swelling in addition to validating the double-infiltration test setup. Conventional free swell tests and centrifuge tests were performed on samples of Cook Mountain clay that were compacted with either a disperse (compacted wet of Standard Proctor optimum moisture content) or flocculated (compacted dry of optimum moisture content) structure. It was observed that, when samples are tested at the same initial moisture content, flocculated soils tend to swell less than dispersed soils. Additionally, flocculated soils tend to swell more quickly and exhibit less secondary swell than dispersed soils.

Additionally, the double-infiltration permeameter setup was found to compare favorably with the setup used with ASTM D4546. Figure 2-16 shows an example test comparison between the two methods. The double-infiltration method was found to reach the end of primary swelling more quickly than the free swell setup and exhibited less secondary swelling, while still providing comparable values of end-of-primary swell. Additionally, the new setup decreased test variability with respect to overburden pressure and the dependence of water height on the effective stresses acting on the sample.

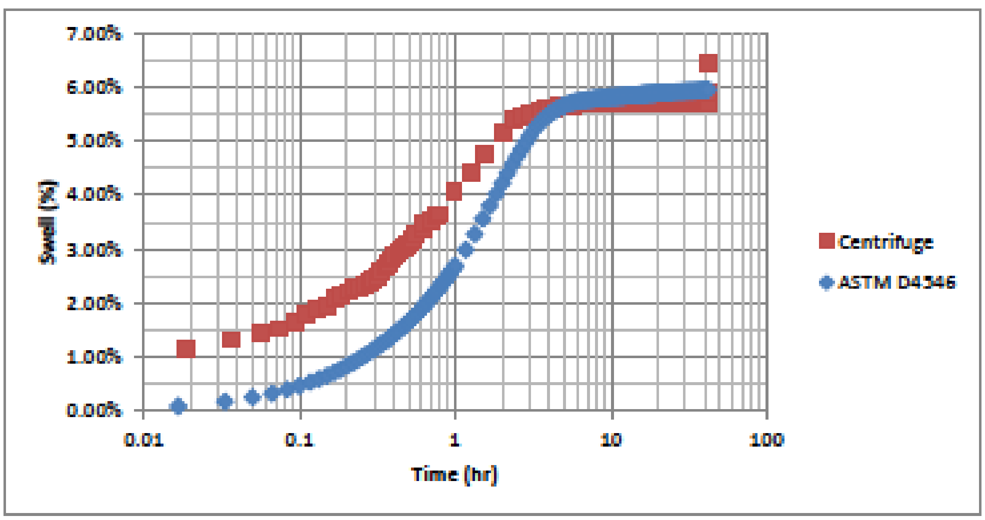


Figure 2-16. Comparison of Swell-Time Curves from Centrifuge Double-Infiltration Setup and ASTM D4546 Setup (Armstrong 2014)

3. DESCRIPTION OF PVR METHODS

3.1. Index Method (TEX-124-E)

The method of calculating PVR currently used by the Texas Department of Transportation (TxDOT) is based on work performed by Chester McDowell (1956). This method was developed as an attempt to understand the variables involved in the shrinkage and swelling of soils. Using experimental data from three soils from Guadalupe County, Texas, the following predictive relationships regarding soil index properties and swell potential were developed:

- A relationship between volumetric swell and linear swell, shown in Figure 3-1.
- A relationship between moisture change and volume change for expansive soils. This was developed as relationships between the soil's plasticity index and the amount of volumetric swelling observed under 1 psi overburden pressure. This data was plotted for 3 different moisture conditions in Figure 3-2.
- A relationship between soil's moisture content and its liquid limit, determined from clays below pavement subgrades. This relationship provides a "wet", "dry", and "average" condition, calculated using equations 3-1, 3-2, and 3-3, and were used in the plots shown in Figure 3-2.
- A stress-swell relationship between the soils, shown in Figure 3-3. This figure was prepared using oedometer swell tests at varying stress levels to create a family of stress-swell curves differentiated by the amount of volumetric swell observed at 1 psi.
- A method of calculating the potential vertical rise (PVR) of layered systems.
- A relationship between plasticity index and the thickness of a soil layer to its PVR.
- A relationship between PVR and the behavior of overlying structures.

$$\omega_{dry} = 0.2LL + 9 \qquad Eq.\ 3-1$$

$$\omega_{wet} = 0.47LL + 2 \qquad Eq. 3-2$$

$$\omega_{avg} = \frac{\omega_{wet} + \omega_{dry}}{2} \qquad Eq. 3-3$$

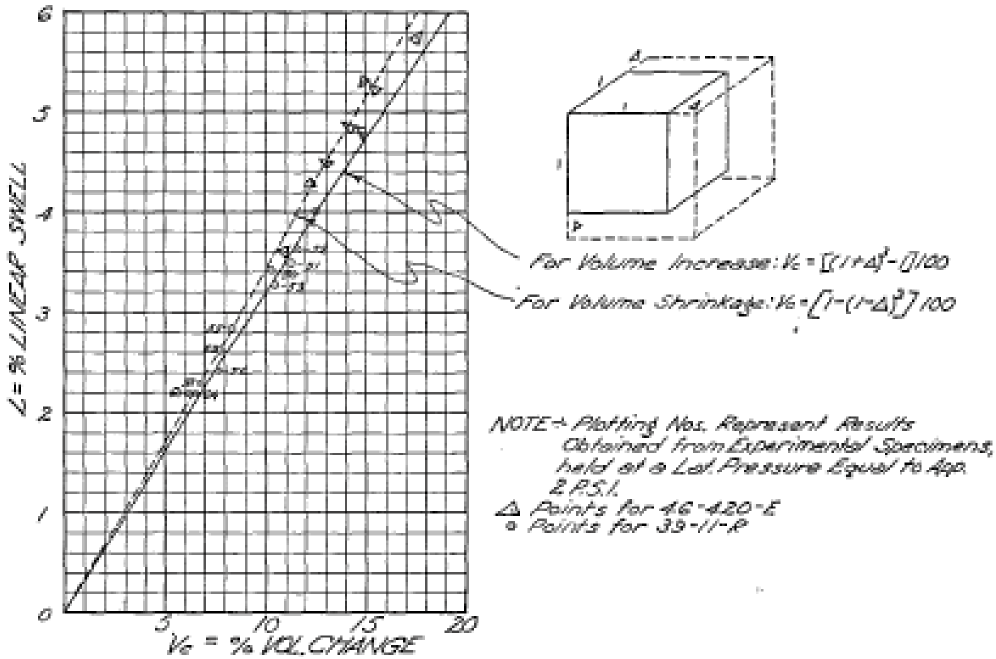


Figure 3-1. Volumetric Change Relation with Linear Swell (McDowell 1956)

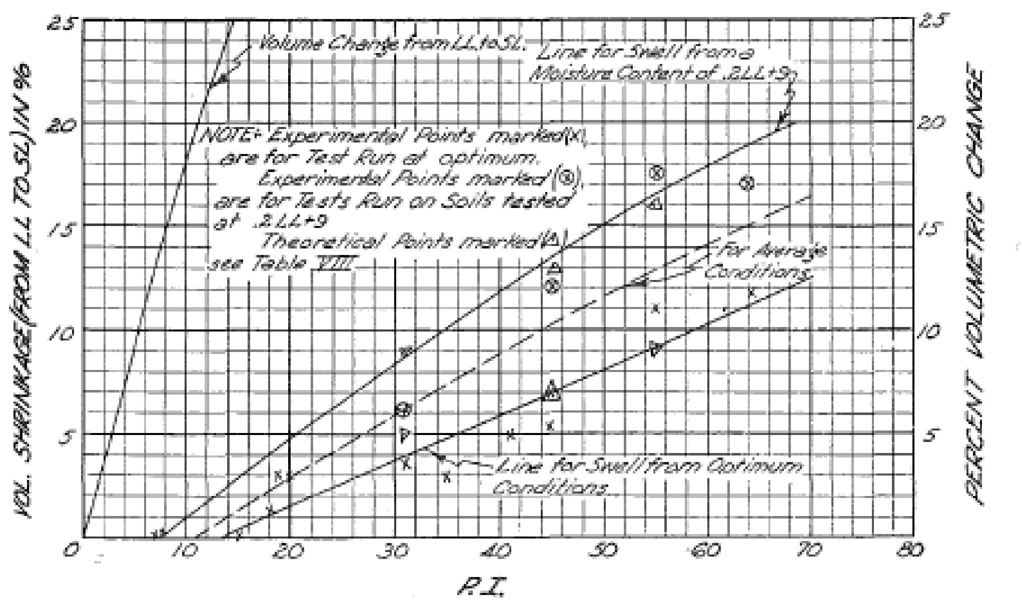


Figure 3-2. Plasticity Index Relation with Volumetric Change (McDowell 1956)

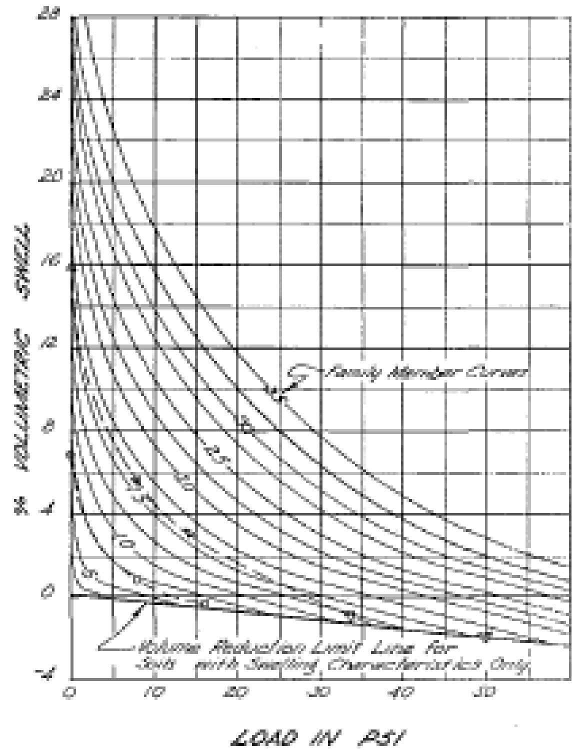


Figure 3-3. Volumetric Stress-Swell Curve Family (McDowell 1956)

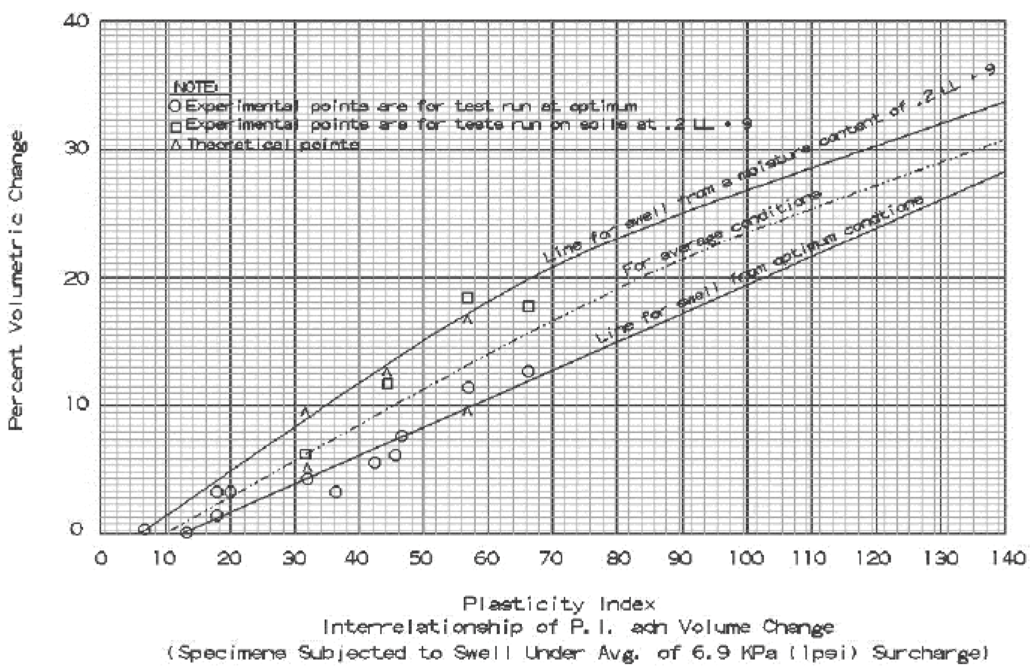


Figure 3-4. Plasticity Index Relation with Volumetric Swell (TxDOT 1999)

This approach was used by TxDOT and modified in 1999 to become the current method detailed in TEX-124-E. First, the plasticity-volume change plots shown in Figure 3-2 were extrapolated to plasticity indices of up to 140, shown in Figure 3-4. Additionally, the stress-swell curves shown in Figure 3-3 were replaced by a family of curves that directly calculate the PVR from an applied load, seen in Figure 3-5.

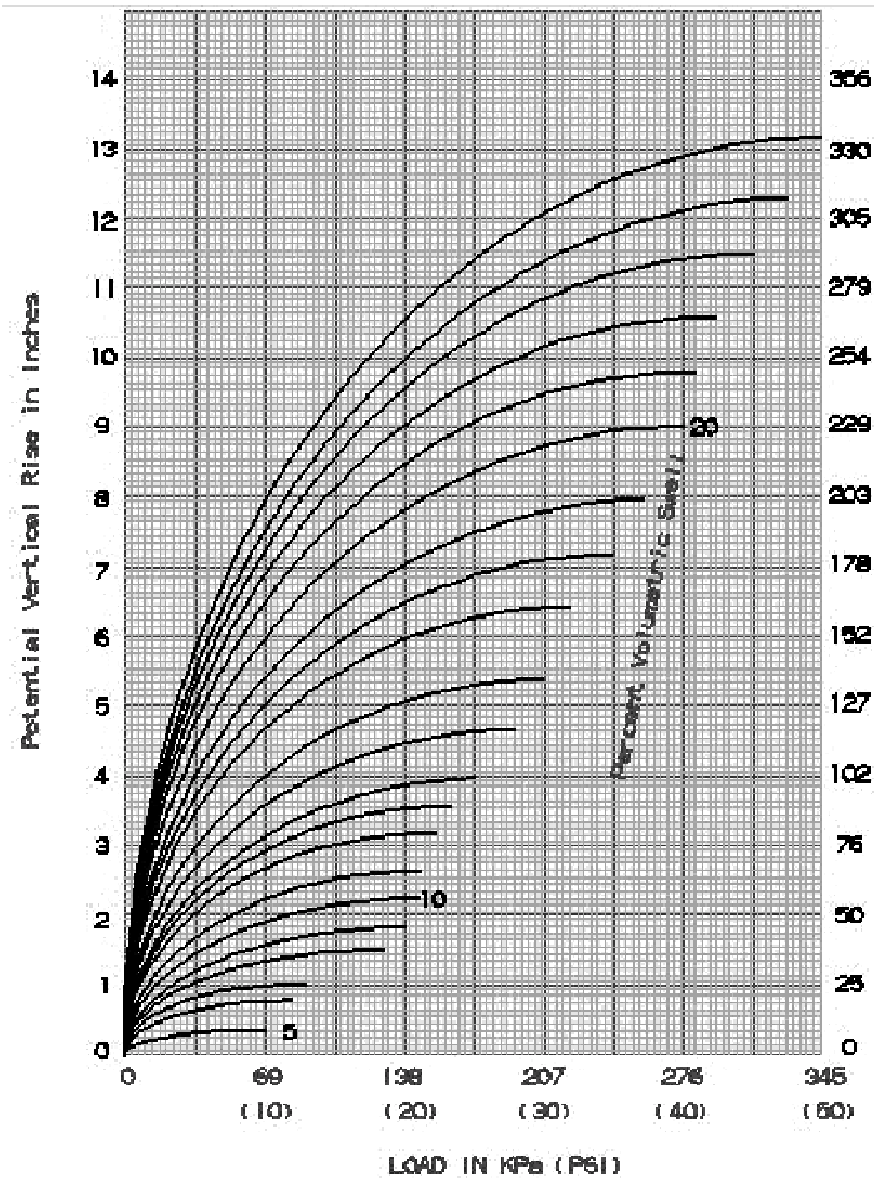


Figure 3-5. Modified PVR-Stress Curve Family (TxDOT 1999)

The TEX-124-E method is described below, and a calculation spreadsheet template is shown in Figure 3-6. For each 2-ft section of the soil stratum, the following index parameters are required: liquid limit, plasticity index, measured moisture content, and percent soil binder. The liquid limit is used to calculate reference “wet” and “dry” moisture content conditions per equations 3-1 and 3-2, which are then compared to the measured moisture content at each depth. Depending on the soil’s plasticity index and how the measured moisture content compares to the “wet”, “dry”, or “average” moisture contents, a percent volume swell is determined via Figure 3-4. This value is converted to a “free swell” value per the following equation:

$$Free\ Swell = (Volume\ Swell) * 1.07 + 2.6 \qquad Eq. 3-4$$

The calculated swell, in conjunction with the effective stress on the top and bottom of each layer, are used with the plots in Figure 3-5 to calculate the PVR at the top and bottom of each layer. The differential swell for each layer is then adjusted with factors for the percent soil binder and the unit weight of the soil (assumed to be 125 pcf in the charts) and then summed over the soil stratum to produce the total PVR for each layer.

PVR Data BH

	Depth to Bottom of Layer [ft]	Average Load [psi]	Liquid Limit (LL)	Dry 0.2LL+9	Wet 0.47LL+2	Percent Moisture	Dry Avg Wet	Percent -No.40	Plasticity Index (PI)	Percent Volume Swell	Percent Free Swell	PVR [in] Top of Layer	PVR [in] Bottom of Layer	Differential Swell [in]	Modified -No.40 Factor	Modified Density Factor	PVR in Layers [in]	Total PVR [in]
0	0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.00**
1		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
2		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
3		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
4		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
5		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
6		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
7		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
8		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
9		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**
10		0.0		9.0	2.0		Dry			0.0	0.0	**0.00**	**0.00**	0.00	0.00	1.00	0.00	**0.00**

Fields are chart inputs — Fields are final answers per layer — Final Total PVR for the borehole

Note: PVR calculations are based on future pavement grade being the same as present grade. Bold numbers are interpolated and extrapolated values.

Figure 3-6. TEX-124-E PVR Calculation Template

While this method is fairly simple to implement, there are a number of limitations. First, the swell data is taken from only 3 soils in one county and assumed to represent expansive soils throughout the state. Second, the method provides one measure of swell for three moisture content conditions, each of which covers a range of moisture contents. It has been shown previously (and is corroborated in Chapter 5) that relatively small changes in soil moisture content can significantly impact its swell potential (Walker 2012). Additionally, no moisture contents outside of the “wet” and “dry” range were tested for this method. Lastly, there has only been limited corroboration of the TEX-124-E calculated PVR with actual field swelling (Zornberg, Kuhn, and Plaisted 2008; Snyder 2015).

3.2. Direct Measurement of Swell using Centrifuge Tests and Curve Fitting Function

A direct method of determining the PVR of a soil horizon using centrifuge technology was tested and documented by Larson Snyder at The University of Texas at Austin as part of his master's thesis. This method is referred to as the DMS-C approach, or Direct Measurement of Swelling using Centrifuge technology. Data from the linear position sensors is analyzed to produce a swell-time curve for each centrifuge test sample. The swell as determined from the end of the primary swelling phase is then plotted against the effective stress acting on the specimen, which is dependent on the centrifuge g-level, the weight of the top porous disc on the sample, and the amount of water added to the sample. Tests were performed at 3 g-levels to produce swell data for a range of effective stresses between approximately 100 psf and 1000 psf.

A curve fitting function was developed to apply to the stress-swell data, which could then be numerically integrated to calculate the PVR of the soil stratum. The curve fitting function, shown in Equation 3-5, is based on a model developed by Plaisted, 2015, and requires 3 fitting parameters. A represents the "free swell" of the soil, or the swell measured at 1 kPa. B represents the minimum swell of the soil. C is a curve-fitting variable; after analysis of several values of C, it was determined that a value of 60 produced the best fit curve. The final equation used is shown in Equation 3.6 and requires 2 parameters. Solving for the curve-fitting parameters A and B is completed by using the Solver function in Microsoft Excel to minimize the root mean square error (RMSE) of the function (Equation 3-7). An example curve is shown in Figure 3-7.

$$\epsilon(\sigma') = \frac{(A-B)\ln(0.01C+e)}{\ln\left(C\frac{\sigma'}{\sigma'_{ATM}}+e\right)} + B \qquad Eq.3-5$$

$$\epsilon(\sigma') = \frac{(A-B)*1.197}{\ln\left(60\frac{\sigma'}{\sigma'_{ATM}}+e\right)} + B \qquad Eq.3-6$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(\epsilon_{measured,i} - \epsilon_{calculated,i}\right)^2}{n}} \qquad Eq. 3-7$$

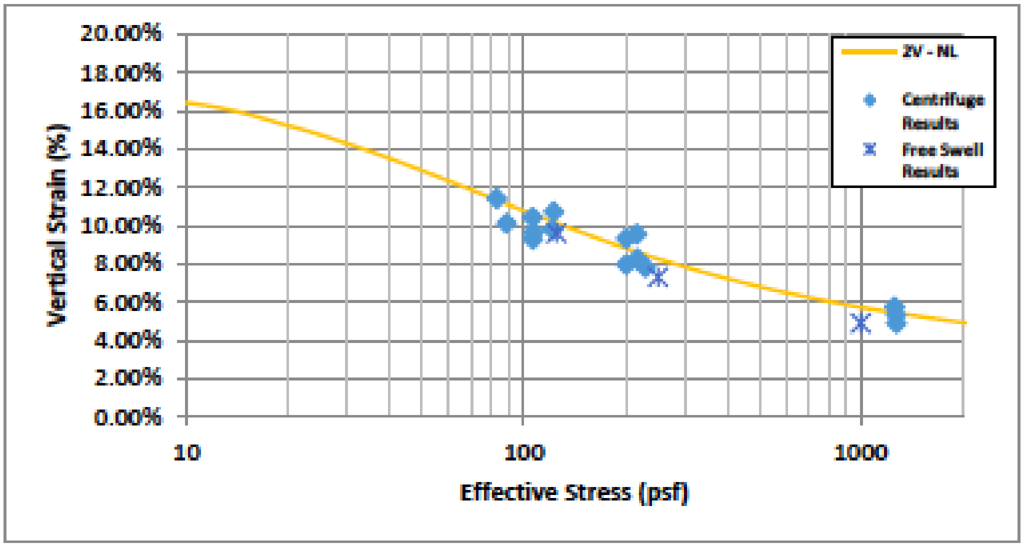


Figure 3-7. Example of Equation 3.6 Fit to Stress-Swell Data (Snyder 2015)

The curve fitting function was later adjusted, and another variable was added, resulting in Equation 3-8. Here, the A parameter continues to represent the "free swell" value, and D is a curve-fitting parameter that is taken to be 60. The B and C parameter differ, however – here B affects the curvature of the inflection point, and C affects the effective stress at which the inflection point of the curve occurs. The equation is solved in the same way as the previous iteration – via the Solver function in Excel. The parameters A, B, and C are adjusted to minimize the RMSE of the curve fitting equation. An example of the curve fit to stress-swell data is shown in Figure 3-8.

$$\epsilon(\sigma') = A\frac{\ln\left[\left(\frac{D * 20.89}{C * \sigma'_{ATM}}\right)^{B\left(1+\left(\frac{20.89}{C*\sigma'_{ATM}}\right)^{1.5}\right)^{8}} + e\right]}{\ln\left[\left(\frac{D * \sigma'}{C * \sigma'_{ATM}}\right)^{B\left(1+\left(\frac{\sigma'}{C*\sigma'_{ATM}}\right)^{1.5}\right)^{8}} + e\right]} \qquad Eq. 3-8$$

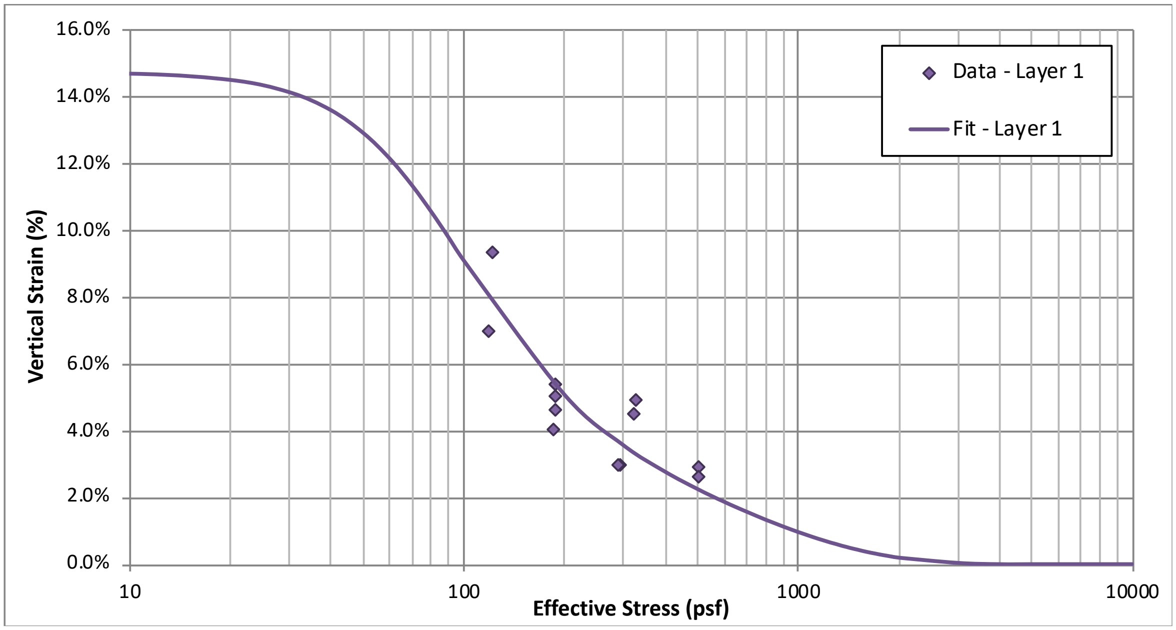


Figure 3-8. Example of Equation 3.7 Fit to Stress-Swell Data

These curve fitting functions have the benefit of being a fairly accurate representation of site-specific stress-swell data. However, the curves generally require at least 3-4 distinct data points (or at least one full centrifuge test) per soil layer. Particularly when a lime-treated PVR estimate is desired and several lime dosages must be tested for each soil, the number of tests required adds up significantly. Thus, a reduced procedure for producing site-specific untreated and lime-treated stress-swell curves is desired.

3.3. Direct Measurement of Swell using Centrifuge Testing and Log-Linear Function

It can be inferred for both curve fitting functions discussed in Chapter 3.2 that the stress-swell curve very closely approximates a straight line in semi-log space for an effective stress range of 100 psf – 1000 psf, which is the general stress range of interest in PVR calculations of a soil stratum. Additionally, Zornberg and Armstrong (2015) provide the option for a log-linear fit to centrifuge-produced stress-swell data to calculate a PVR for the soil stratum. The proposed log-linear curve-fitting function is shown in Equation 3-9, where parameters A and B are the slope and intercept of the line, respectively.

$$\epsilon(\sigma) = A * \log \sigma + B \qquad Eq. 3-9$$

An example of stress-swell data fit to a log-linear function is shown in Figure 3-9. The orange line denotes untreated expansive clay, while the purple and green lines denote expansive clay treated with 1% and 2% hydrated lime, respectively. While each data set closely follows a log-linear stress-swell relationship, the point at which each line intersects the x-axis, the swell pressure, varies.

Previous research has looked into the effect of varying soil properties on swell pressure, including compaction moisture content, compaction density, and lime content. Basma et al 1995 found that the swell pressure obtained for a given soil increases with dry unit weight and decreases with increasing compaction moisture content. Al-Rawas et al 2005 found that, for an expansive soil native to Oman, the soil's swell pressure decreased with an increasing amount of added lime.

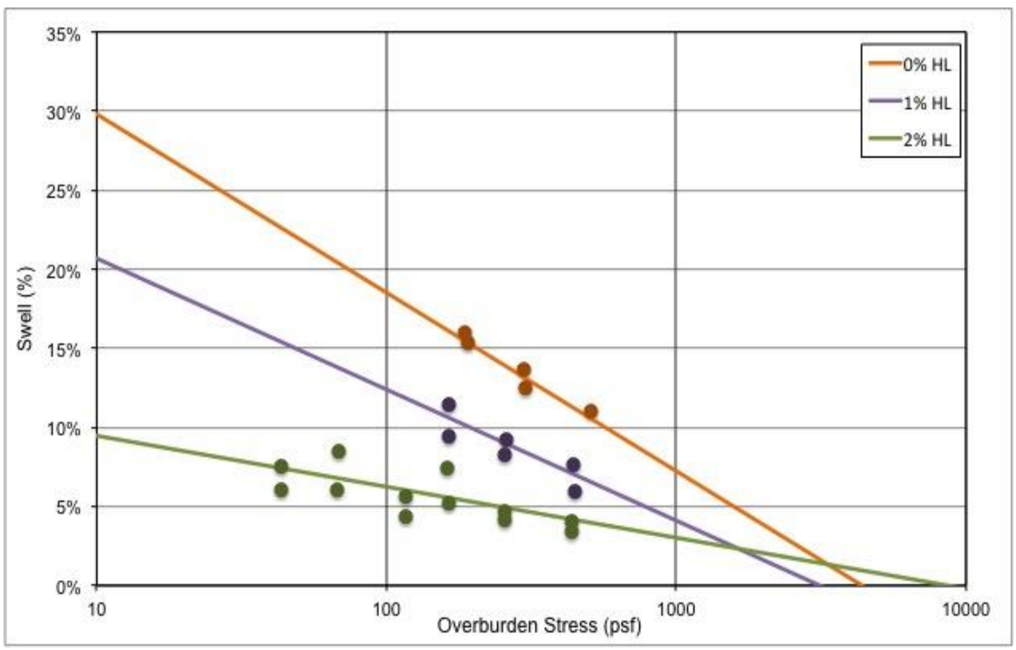


Figure 3-9. Example Stress-Swell Data for Untreated and Lime-Treated Expansive Clay

The *assumption* of a constant swell pressure may allow for the development of a reduced testing procedure for both untreated and lime-treated expansive clays. A possible justification is that the volume of "expansive" material being stabilized in a given volume of soil is independent of stress. Figure 3-10a illustrates the idealization of the plots in Figure 3-9 where all three stress-swell curves converge to a single swell pressure. The goal is that, for an effective stress range of approximately 100 psf to 1000 psf, the variation in lime-treated stress-swell curves from a best-fit line to a line of constant swell pressure will result in a reasonably similar line. This range of stresses is used as a guideline to match the stresses acting over the upper 10 feet of soil below a pavement and base layer system. Moreover, the area under the lines plotted in Figure 3-10a are to be reasonably close to the area under the lines plotted in Figure 3-9, thus resulting in the same or nearly-the-same calculations of PVR.

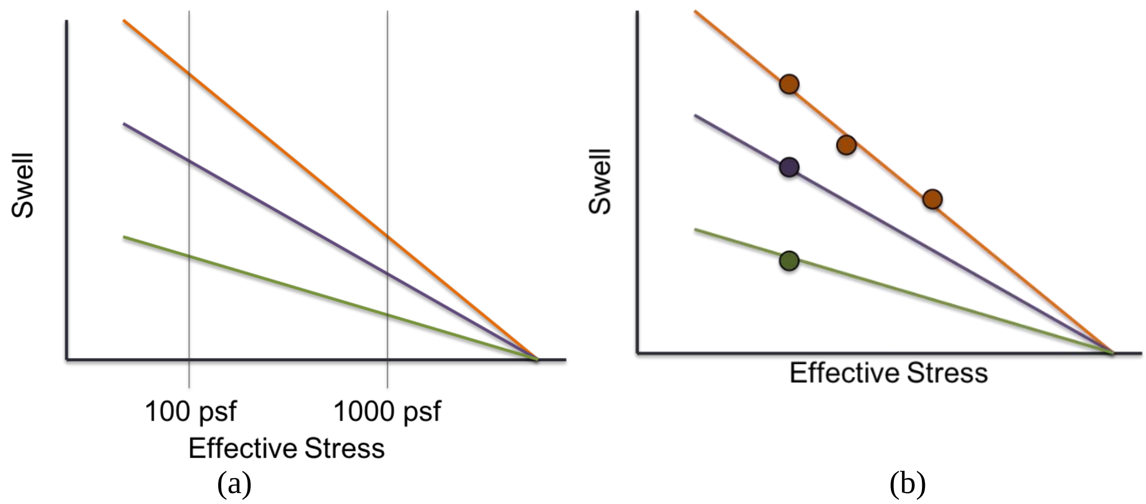


Figure 3-10. (a) Example of Converging Stress-Swell Curves, (b) Example of Optimized Method of Producing Stress-Swell Curve Family

Figure 3-10b illustrates the approach for the “Optimized Method” of producing a lime-treated stress-swell curve family for a given soil. This approach can be decoupled into 2 evolutions: first, the effect of effective stress on swelling for a constant amount of lime, and second, the effect of added lime on swelling for a constant effective stress. The orange data points and line represent a stress-swell curve produced for the untreated soil in a given location, while the purple and green data points and line represent stress-swell curves produced for two different lime dosages for the same soil. A full stress-swell curve, using points for at least 3 effective stresses, will be produced for the untreated soil. For a number of lime dosages, the swell at a prescribed effective stress will be measured. This data point for each lime dosage will be extended to match the extrapolated swell pressure of the untreated soil to create a family of lime-treated stress-swell curves, with which the lime-treated PVR of the soil may be calculated. This method will be corroborated by data shown in Chapter 5, and further examples of calculating lime-treated PVR will be shown in Chapter 7.

4. SOURCES OF VARIABILITY IN CENTRIFUGE TEST RESULTS

There is an intrinsic amount of scatter in results of centrifuge tests within otherwise identically compacted samples, usually on the order of 2-3%. While some of this variation is due to heterogeneity within soil mineralogy and the arrangement of voids within the soil sample, some variation may be due to inconsistencies or variation in test preparation. This chapter seeks to identify possible sources of variability and observe their effect on swell potential of otherwise identically compacted samples.

4.1. Use of Vacuum Grease

The use of vacuum grease on the inside of the aluminum cutting rings of the test samples is intended to reduce friction and allow the samples to swell to their full potential. However, it is also possible that excess amounts of vacuum grease become mixed into the soil during compaction and affect inundation and swelling around the sample edge. To evaluate this, a series of samples of untreated Eagle Ford were compacted in clean aluminum cutting rings using: 1) no vacuum grease, 2) a "typical" amount of vacuum grease, or 0.05 g, and 3) a "large" amount of vacuum grease, or 0.1 g. The amount of vacuum grease was determined by weighing the aluminum ring before and after coating the inside with vacuum grease. The samples were then tested at an effective stress level of approximately 235 psf (calculated stress values range from 233 psf – 238 psf). The range of compaction conditions for the tested samples is shown in Table 4-1, and the swell data for the samples is shown in Figure 4-1.

Table 4-1. Range of Initial Compaction Conditions for Test Data Shown in Figure 4-1

	Moisture Content [%]	Compaction Void Ratio [ ]	Dry Density [pcf]
Minimum Value	23.2%	0.831	93.9
Maximum Value	23.6%	0.847	95.1
Percent Difference	1.8%	1.3%	1.9%

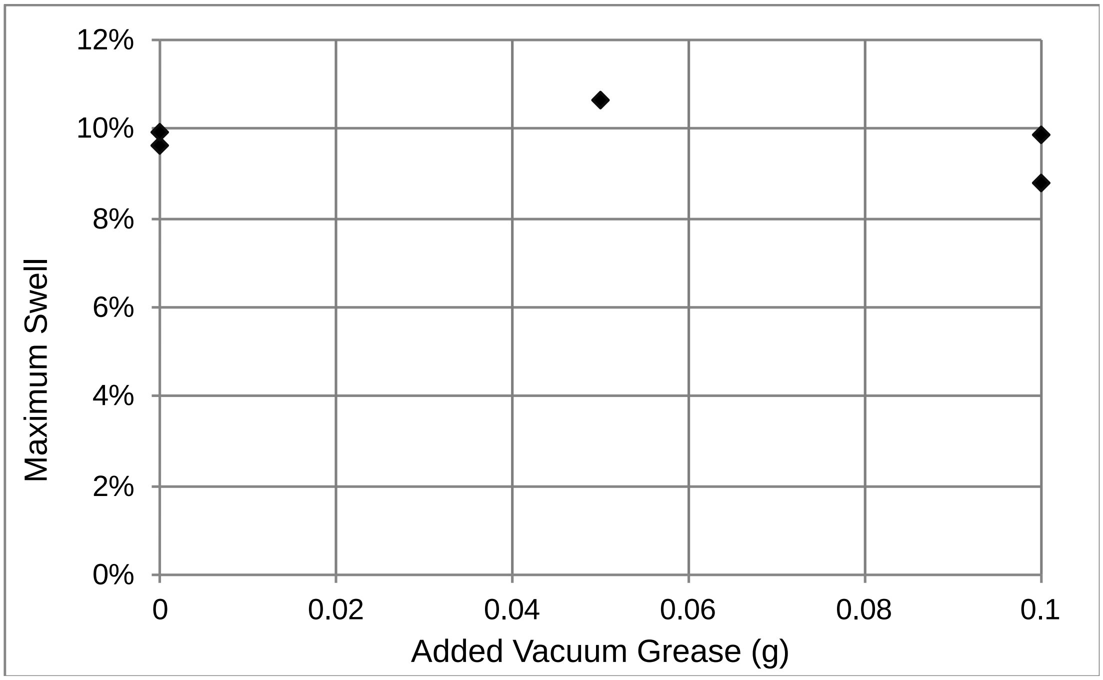


Figure 4-1. Variation of Maximum Swell with Vacuum Grease Use for Untreated Eagle Ford

It can be seen that the swell values among the 5 samples vary by about 2% (8.8% to 10.6%), which is within an acceptable margin of error. However, it can be observed that the samples tested with a "large" amount of vacuum grease swell slightly less and with a larger variance than the samples tested without vacuum grease, and that the sample tested with a "typical" amount of vacuum grease swelled more than the others.

4.2. Air-Dry vs Oven-Dry Samples

Next, the difference in swell between samples prepared with air-dried and oven-dried soil was observed. While it is always preferable to test on air-dried soil, the idea of processing and reusing already tested soil samples may be appealing, particularly when limited amounts of soil are obtained for a given test series. However, when soil is dried at high temperatures it can irreversibly affect its structure. This is particularly notable in soils with high organics content, but can also affect highly expansive soils, as the removal of water molecules attached to clay particles occurs at a higher rate at higher drying temperatures. This can effectively destroy the soil structure and has been noted to markedly decrease the soil plasticity and swell potential (Basma et al 1994). To assess this, samples of air-dried and oven-dried processed Eagle Ford clay were prepared at a target moisture content of 24% and a target dry density of 95 psf and tested at an effective stress of approximately 200 psf (calculated stress values range from 196 psf – 200 psf). Table 4-2 provides the range of initial compaction conditions for the samples tested.

Table 4-2. Range of Initial Compaction Conditions for Test Data Shown in Figure 4-2

	Moisture Content [%]	**Compaction Void Ratio [ ]**	**Dry Density [pcf]**
Minimum Value	23.4%	0.836	92.8
Maximum Value	24.8%	0.849	93.6
Percent Difference	6.2%	0.9%	1.6%

Figure 4-2 plots the points in log(stress)-swell space. As can be seen, the oven-dried samples, on average, swell about 1.3% less than the air-dried samples, although the variance between samples is nearly the same in each case (a difference of 1.4% in swell potential for otherwise identically compacted samples).

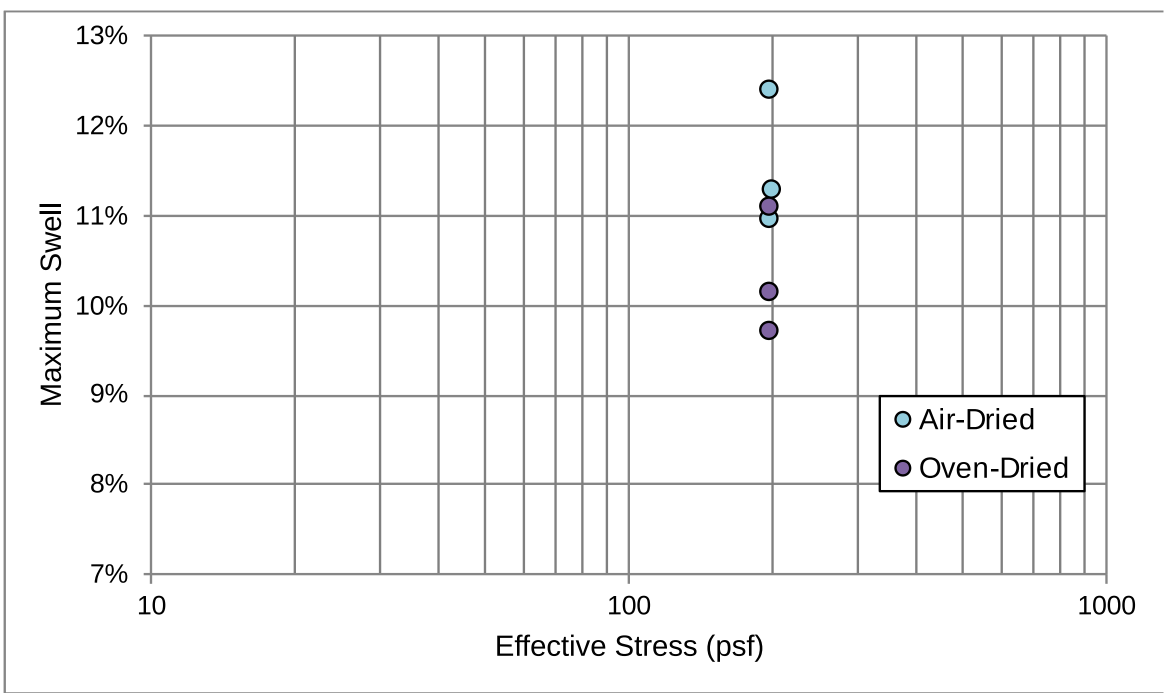


Figure 4-2. Variation of Maximum Swell for Untreated Air-Dried and Oven-Dried Eagle Ford

To better view the data, Figure 4-3 plots the swell potential at 200 psf as a function of compaction moisture content. It can be seen that the oven-dried samples were compacted at a slightly lower moisture content than the air-dried samples (an average moisture content of 23.6% for oven-dried versus an average moisture content of 24.7% for air-dried). As the drier samples are expected to have a higher swell potential, other factors being constant, it can be further seen that oven-dried samples have a markedly lower swell potential than air-dried samples, and that it would be inappropriate to aggregate swell data from both types of soil.

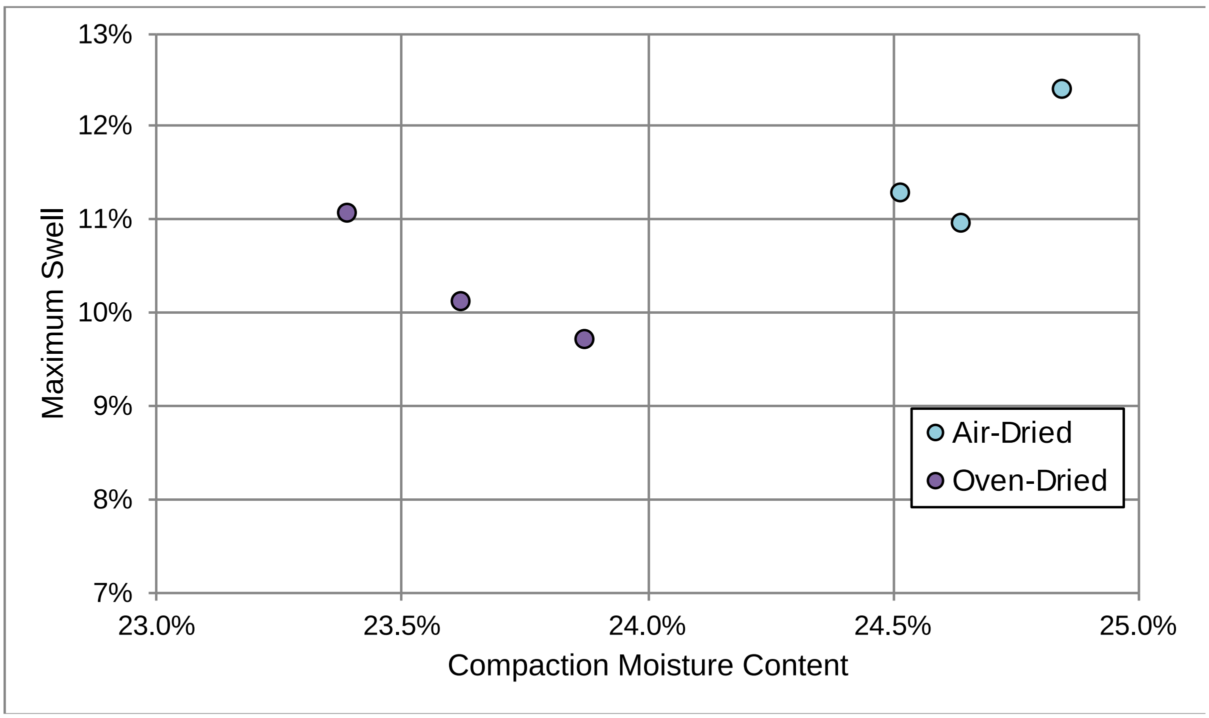


Figure 4-3. Variation of Maximum Swell with Initial Moisture Content for Untreated Eagle Ford Clay at 200 psf

4.3. Amount of Water Added to Test

In addition to sample preparation, the amount of water added to each test to initiate swell was considered in the sources of variation. The amount of water added can affect the test in two ways: first, the level of ponded water over the sample will affect the effective stress acting on the sample, and secondly, if the sample is not fully inundated throughout the test, then the sample may not express its full swell potential. To observe any potential effects, samples of air-dry processed Eagle Ford clay were prepared at a target moisture content of 24% and a target dry density of 95 psf and tested at an effective stress of approximately 165 psf (calculated stress values range from 164 psf – 169 psf). Samples were then inundated under either 50 mL, 60 mL, or 100 mL of water and allowed to swell. Table 4-3 provides the range of initial compaction conditions for the samples tested.

Table 4-3. Range of Initial Compaction Conditions for Test Data Shown in Figure 4-4

	Moisture Content [%]	**Compaction Void Ratio [ ]**	**Dry Density [pcf]**
Minimum Value	23.4%	0.818	92.5
Maximum Value	24.7%	0.861	94.5
Percent Difference	5.6%	5.2%	2.2%

Results of the test may be seen in Figure 4-4. It can be seen that the total swell variance over the tests is 3.2%, which is a slightly higher margin of error than is ideal. It can also be seen that the samples inundated with 100 mL of water tended to swell more and swell more consistently than samples inundated under 50-60 mL of water. It is interesting that the samples tested with 60 mL of water swelled less than any of the other samples; however, this is likely due to the higher moisture content of these samples as compared to the others (the samples tested with 60 mL of water were compacted at 24.7%, whereas the other samples were compacted at 23.4% - 23.7%).

Two takeaways can be obtained from this exercise: samples that are tested using the same amount of water (within 5 mL) will not likely see a marked variation in swell due to the amount of water added; and it is recommended that the full 100 mL of water be used for testing, as this is likely to provide more consistent test results and gives a lower chance that the sample runs out of water during the test.

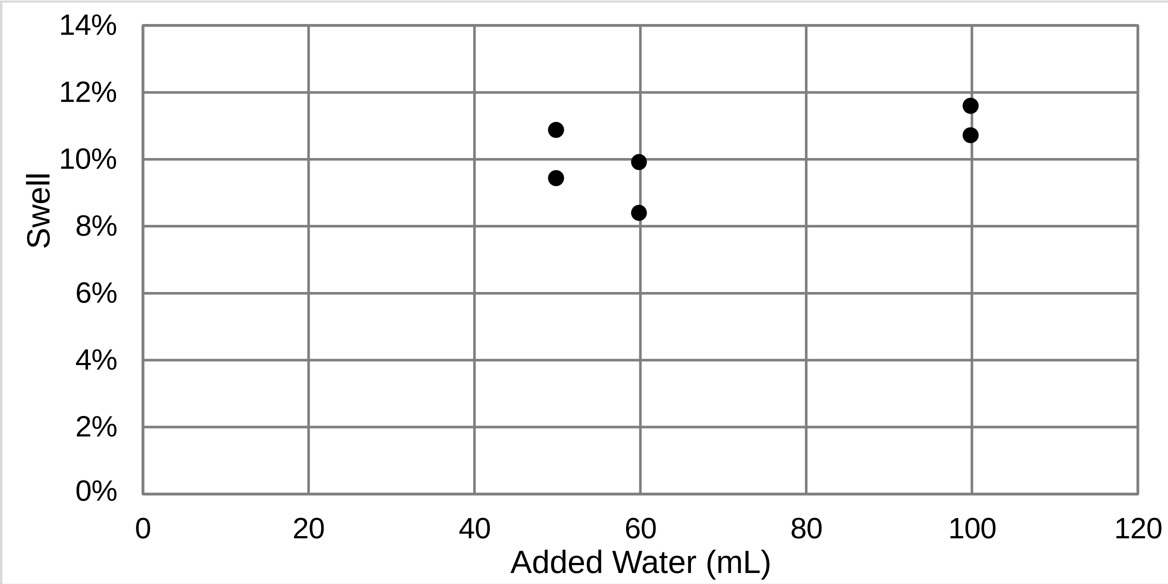


Figure 4-4. Variation of Swell with Amount of Water Added for Swell for Untreated Eagle Ford

4.4. Recalibration of Centrifuge LPS

An additional consideration was that the linear position sensors (LPS) in the centrifuges had become out of sync and may need recalibrating, which may affect the heights measured in each of the cups. To test the calibration of each LPS, a standard set of porous discs was used in a mock permeameter-centrifuge bucket setup. The height of each disc was measured using a vertical dial indicator, and then the height of each disc or disc set was measured in the centrifuge at 1-g (centrifuge stopped). This process was repeated for each of the 6 LPS in Centrifuge 2 and Centrifuge 3. The results are shown in Figure 4-5 and Figure 4-6. In each plot, the horizontal axis represents the disc height as measured in the external dial indicator, the vertical axis represents the height determined by the LPS, and the solid black line represents the 1:1 line. In each case, the centrifuge LPS underestimates the actual heights measured. However, the ratios are consistent across the sensors in both centrifuges (93% - 95% of the externally measured height). Table 4-4 provides the ratio of calculated height to measured height for each of the sensors.

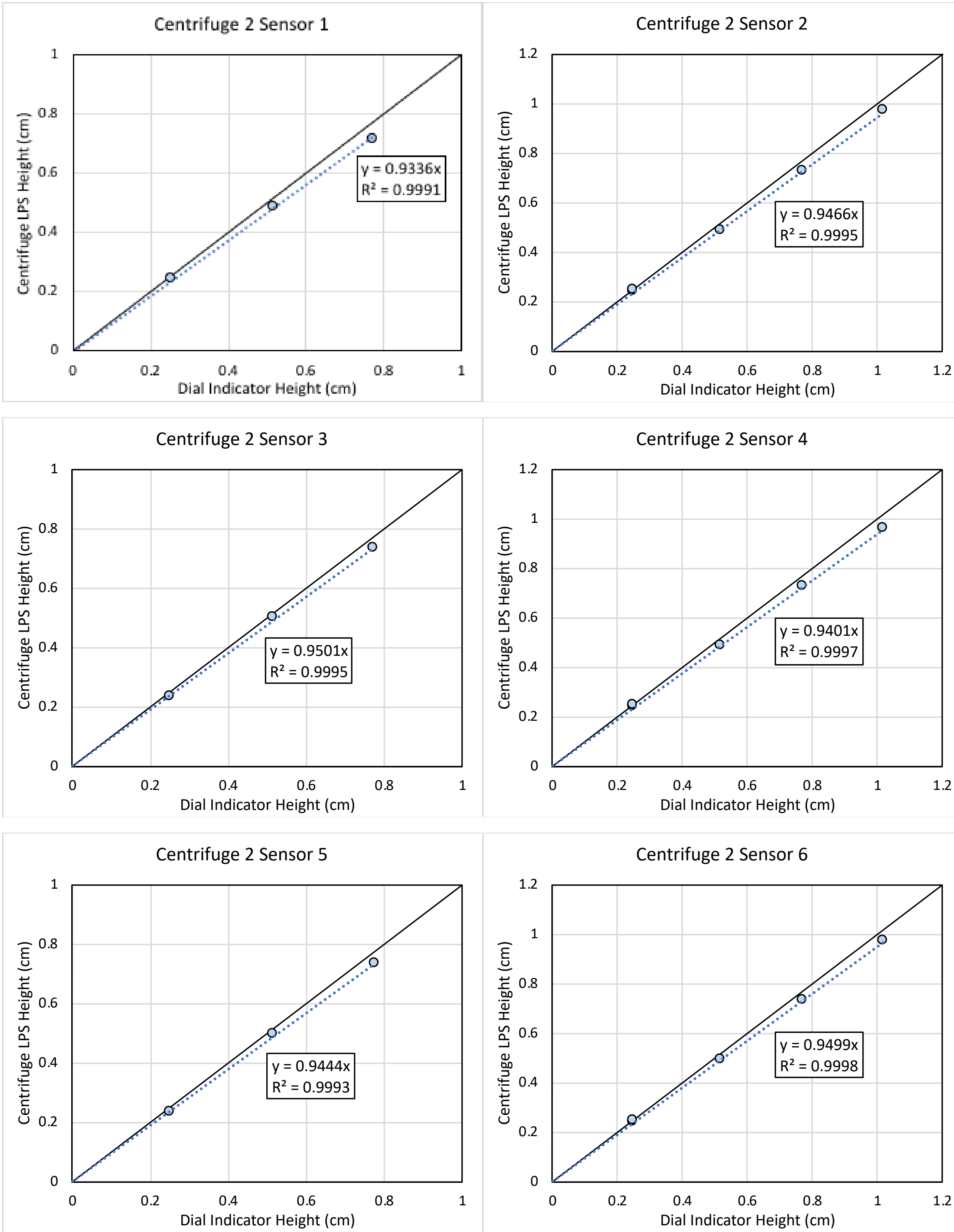


Figure 4-5. Calibration Curves for Centrifuge 2 Linear Position Sensors

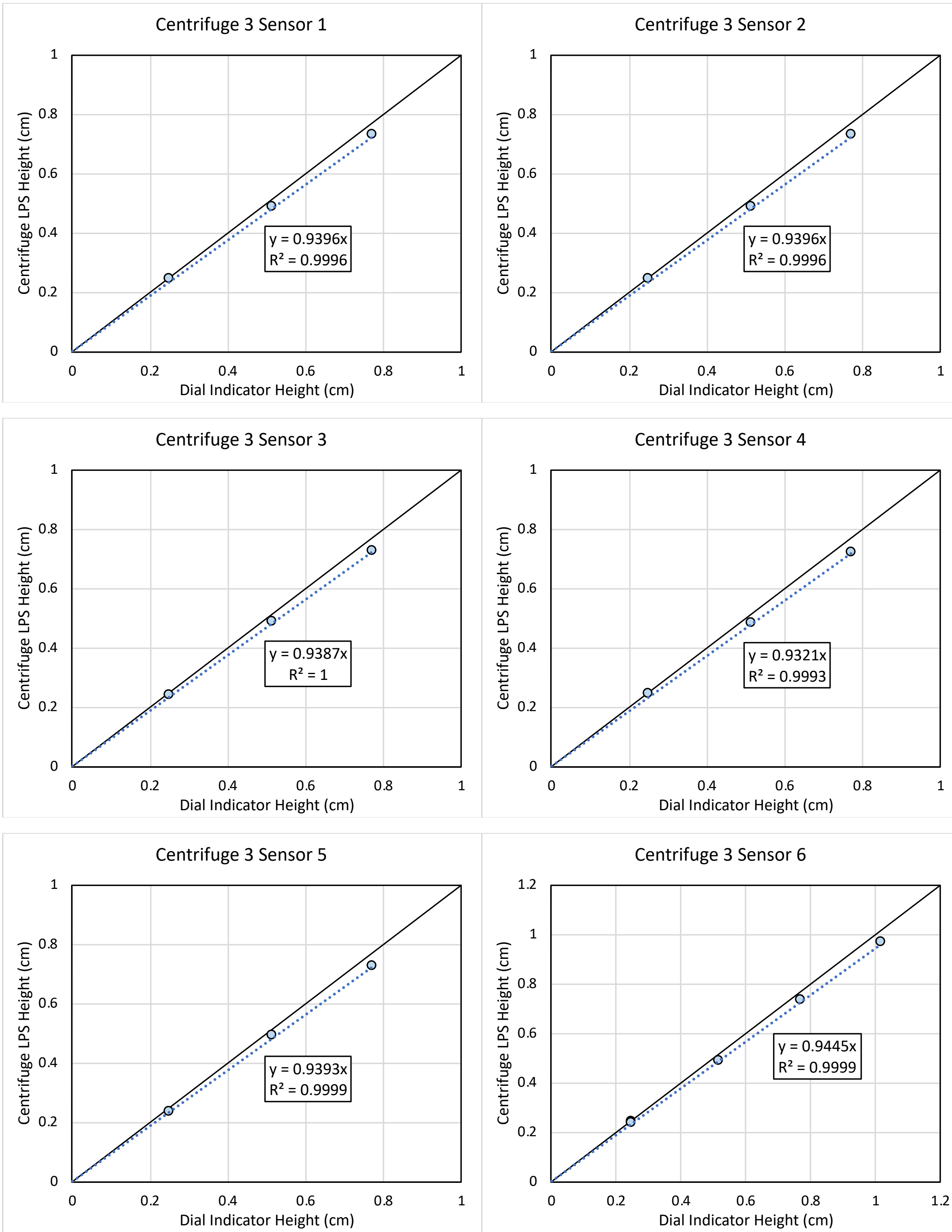


Figure 4-6. Calibration Curves for Centrifuge 3 Linear Position Sensors

As can be seen in Figures 4-5 and 4-6 and in Table 4-4, the height ratios among sensors for each centrifuge are consistent: 93.4%-95.0% for Centrifuge 2, and 93.2% - 94.5% for Centrifuge 3. For this reason, it was determined that the calibration factor for each centrifuge be adjusted by the average calculated-measured height ratio for each centrifuge – 94.4% and 93.9%, respectively. While this exercise did not necessarily illuminate any strong discrepancies between sensors, it is very important to ensure the linear position sensors are properly calibrated, and it is recommended that this process be repeated periodically to check the sensor calibration.

Table 4-4. Calculated-Measured Height Ratios for Centrifuge Linear Position Sensors

Sensor No.	Centrifuge 2 Ratio	Centrifuge 3 Ratio
1	93.4%	94.0%
2	94.7%	94.0%
3	95.0%	93.9%
4	94.0%	93.2%
5	94.4%	93.9%
6	95.0%	94.5%
Average	**94.4%**	**93.9%**

4.5. Mixing Before and After Adding Water

A potential source of variation with testing lime-treated samples is the method of treating and moisture-conditioning the soil. While lime treatment of soil in the field consists of mixing lime into wet soil, laboratory soil samples may not benefit from this preparation, as mixing hydrated lime into air-dry soil allows the user to more easily produce a more homogenous mixture. Figure 4-7a visually compares two lime-treated soil samples. Both cases show Eagle Ford clay treated with 2% by dry mass hydrated lime and moisture conditioned to 24% and allowed to rest for 24 hours; however, the sample on the left has the hydrated lime mixed in after moisture conditioning, and the sample on the right has the hydrated lime mixed into dry soil and then moisture conditioned. It is apparent that the sample on the right is a more homogenous mixture – there are fewer relatively large soil clods and no unmixed areas of hydrated lime. The sample on the left appears to have most of the hydrated lime coated on the surface of the soil clods rather than thoroughly mixed into the sample. Figure 4-7b visually compares the soil samples after compacting, swelling, and oven drying. Again, the sample on the left of the photo was prepared by mixing hydrated lime into moisture conditioned soil, and the sample on the right was prepared by mixing hydrated lime into air-dry soil and moisture conditioned. The presence of large voids is much more apparent in the sample to the left, showing that the sample is not as evenly compacted as the sample on the right.

(a) (b)

Figure 4-7. (a) Moisture Conditioned Eagle Ford with 2% Hydrated Lime, (b) Eagle Ford with 2% Hydrated Lime After Swelling and Oven Drying

Three samples each of Eagle Ford treated with 2% hydrated lime at 24% moisture content were mixed and tested at an effective stress of approximately 150 psf (stresses ranged from 152 psf – 153 psf). Table 4-5 provides the initial compaction conditions for the test data, and Figure 4-8 plots the swell data as a function of compaction moisture content.

Table 4-5. Range of Initial Compaction Conditions for Test Data Shown in Figure 4-8

	Moisture Content [%]	**Compaction Void Ratio [ ]**	**Dry Density [pcf]**
Minimum Value	23.6%	0.811	93.4
Maximum Value	25.3%	0.844	95.0
Percent Difference	7.0%	4.1%	1.7%

It can be seen that the samples mixed dry with lime (‘Lime Before Water’) have a slightly more consistent compaction moisture content and slightly less variation in swell than the samples mixed wet with lime (‘Lime After Water’), which matches with expected results. For ease of preparation and increased sample uniformity, it is recommended that lime-treated soil samples for centrifuge testing be mixed in the order of air-dry soil, hydrated lime, and then water.

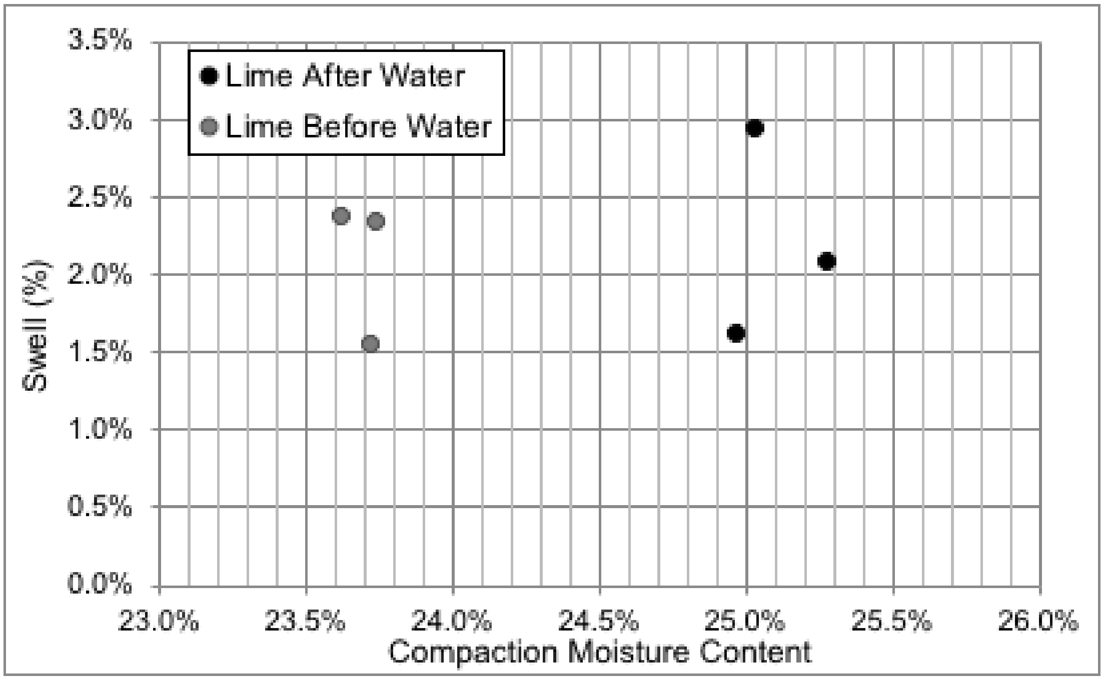


Figure 4-8. Variation of Maximum Swell with Compaction Moisture Content for Eagle Ford Treated with 2% Hydrated Lime at 150 psf

4.6. Height of Samples

Lastly, a preliminary study on the effect of the differential height of samples was performed. Each sample is compacted to a height of 1.00 cm, or 0.394 inches, with height measured in the center of the sample and in 4 points around the sample edge. Generally, a variation of +/- 0.005 inches (+/- 1.2%) is considered acceptable. Because the height during the centrifuge test is measured with a sensor resting on the porous disc atop the soil sample, deviations in height could disproportionately affect the measured height from the centrifuge.

To assess this effect, a subset of the untreated Eagle Ford samples was compared along the aggregate Eagle Ford stress-swell curve. The range of initial compaction conditions used are shown in Table 4-6. The samples were then separated by “maximum differential height”, or the largest height difference between two adjacent measurements on a sample. The maximum differential heights ranged from 0.004 inches to 0.013 inches, and data was separated into categories based on the differential height, as seen in Figure 4-9.

Table 4-6. Range of Initial Compaction Conditions for Test Data Shown in Figure 4-9

	Moisture Content [%]	**Compaction Void Ratio [ ]**	**Dry Density [pcf]**
Minimum Value	23.6%	0.817	92.5
Maximum Value	24.8%	0.861	95.3
Percent Difference	5.4%	5.4%	3.0%

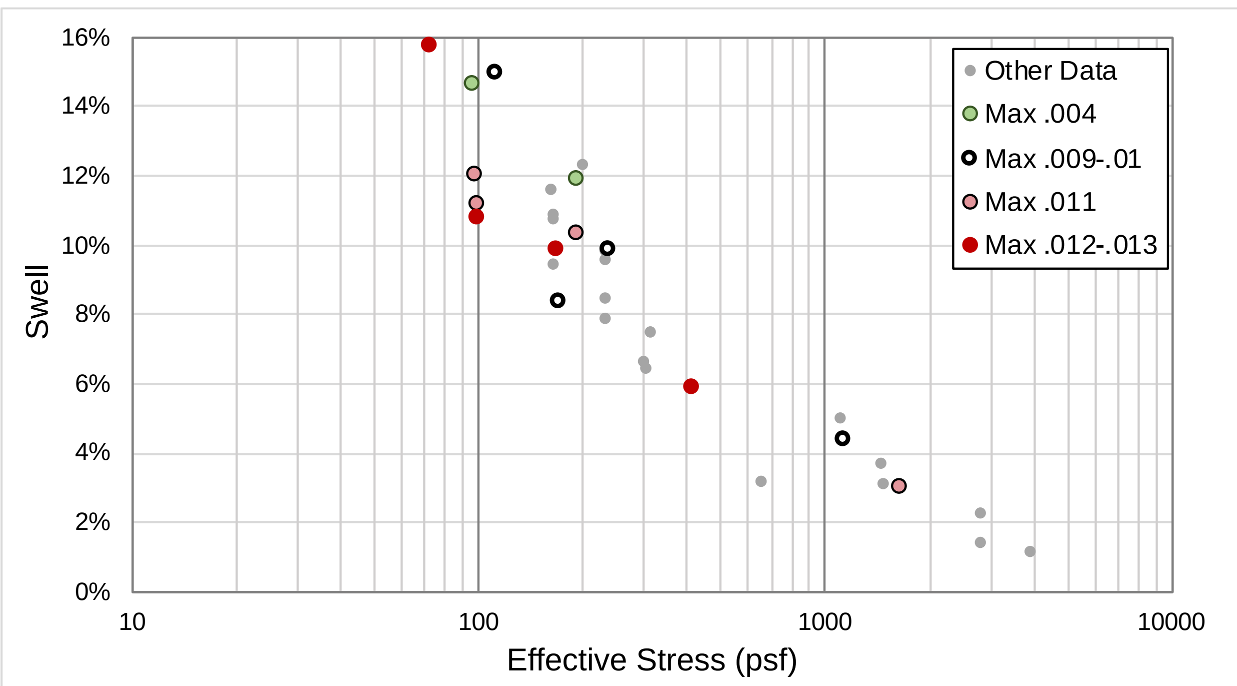


Figure 4-9. Stress-Swell Data for Untreated Eagle Ford Separated by Maximum Differential Height of Sample

It can be seen that the magnitude of the maximum differential height does not seem to significantly affect the magnitude of swell or the amount of variation in the data. This may be due to the fact that more data at very small differential heights is needed. Alternatively, this may point out that a maximum differential height of 0.013 inches (a difference in height of 3.3% for a 0.394-inch sample) is not drastic enough to significantly affect variability. Currently, it is recommended that differential height across the sample be minimized to preferably less than 0.01 inches, but further study on the effect of differential height is likely to be useful in future test preparation.

4.7. Testing Procedure Recommendations

In general, variations in test procedure can be seen to increase variation in swell for otherwise identically prepared and compacted samples. The following recommendations are made to minimize variation in laboratory centrifuge testing of lime-treated expansive clays:

- Vacuum grease be used sparingly so that it does not become mixed with compacted soil around the edges of the cutting ring.
- Air-dry soil be used, rather than oven-dried soil.
- 100 mL water be added to each sample during swell testing.
- Centrifuge LPS calibration be confirmed on a regular basis.
- Soil be mixed with lime when air-dry and then moisture conditioned.
- Sample height vary by no more than +/- 0.005 inches, as measured in 5 points across the sample.

5. CENTRIFUGE TEST RESULTS

The soil used to produce the test results shown in Chapter 4 and Chapter 5 is a shale from the Eagle Ford formation and obtained from Round Rock, Texas. Characterization of the Eagle Ford shale was initially performed by Kuhn 2005 at The University of Texas. A summary of the index properties of Eagle Ford are shown in Table 5-1. Eagle Ford is a highly plastic clay, classified as CH by USCS classification. It is reported to have a liquid limit of 88% and a plastic limit of 39%, giving it a plasticity index of 49.

Table 5-1. Index Properties of Eagle Ford (Kuhn 2005)

Test	Index Parameter	Value	ASTM Standard
Specific Gravity	Specific Gravity, G_s	2.74	D 845-02
Atterberg Limits	Liquid Limit, LL	88	D 4318
	Plastic Limit, PL	39	D 4318
	Shrinkage Limit, SL	18	D 4943
Particle Size Analysis	% Passing 0.075 mm (# 200 Sieve)	97	D 422-63
	% Passing 0.002 mm	76	D 422-63
Standard Proctor Compaction	Optimum water content, %	24	D 1557
	Maximum dry unit weight, $\gamma_{d\,max}$ (kN/m^3)	15.2	D 1557
Modified Proctor Compaction	Optimum water content, ω_{opt} (%)	14	D 698
	Maximum dry unit weight, $\gamma_{d\,max}$ (kN/m^3)	17.8	D 698
Hydraulic Conductivity of Saturated Soil	Hydraulic conductivity of Saturated Soil, K_{sat} (cm/s) (ω = 24%; γ_d= 15.2 kN/m3)	8.9×10^{-8}	D 5084

Figure 5-1 includes the Standard Proctor and Modified Proctor moisture density curves as reported by Kuhn 2005. The maximum dry density and optimum moisture content according to the Standard Proctor Test were reported as 15.2 kN/m^3 (97.5 pcf) and 24%, respectively. The maximum dry density and optimum moisture content according to the Modified Proctor Test were reported as 17.8 kN/m^3 (114 pcf) and 13%, respectively.

Figure 5-2 includes the grain size distribution for Eagle Ford as determined by hydrometer analysis. The soil was found to have 97% passing a No. 200 sieve and 76% clay (passing a 0.002 mm sieve).

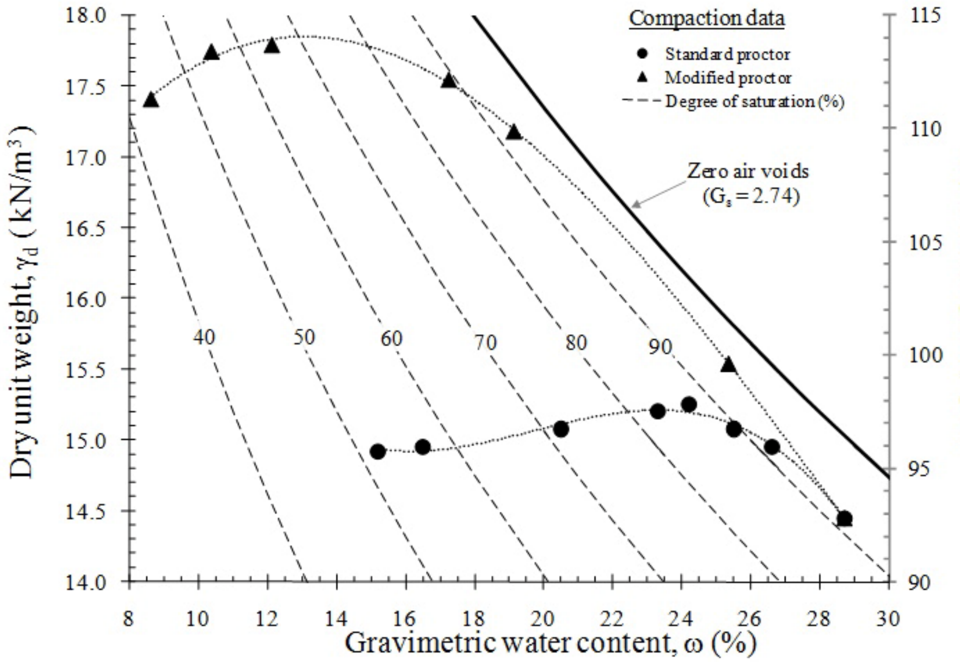


Figure 5-1. Eagle Ford Compaction Curve (Kuhn 2005)

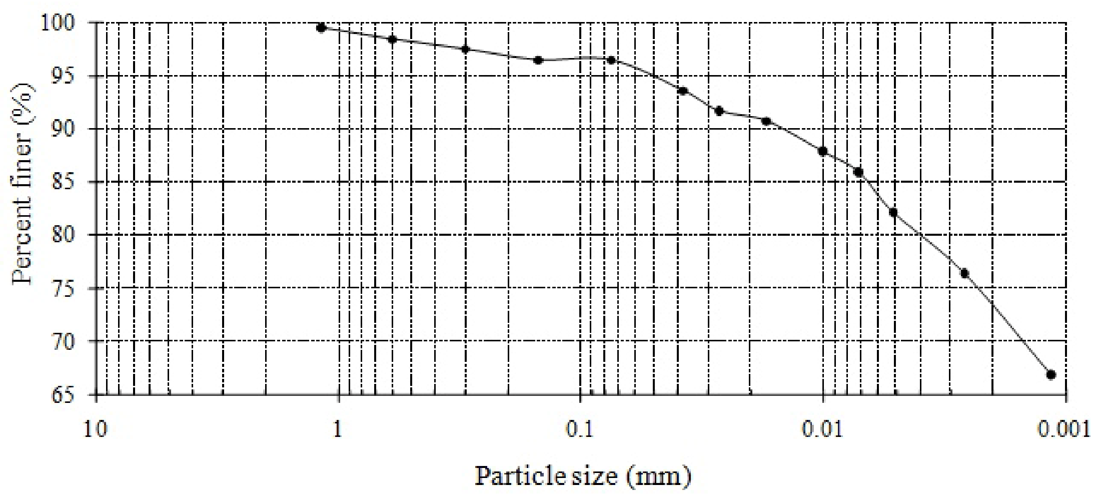


Figure 5-2. Eagle Ford Hydrometer Analysis (Kuhn 2005)

5.1. Untreated Stress-Swell Data

The target compaction conditions used to produce the centrifuge stress-swell data for Eagle Ford are shown in Table 5-2. These compaction conditions are based on the Standard Proctor optimum moisture content and 97% of the Standard Proctor maximum dry density.

Table 5-2. Target Compaction Conditions for Eagle Ford Centrifuge Tests

Target Moisture Content	Target Compaction Void Ratio	Target Dry Density [pcf]
24%	0.820	94.6

First, a range of tests were performed on Eagle Ford to produce a stress-swell curve. The range of compaction conditions are shown in Table 5-3, and the data is presented in Figure 5-3. The data is also presented in Figure 5-4 with both the 3-parameter stress-swell curve and the semi-log stress-swell line with their corresponding r^2 values.

Table 5-3. Range of Compaction Conditions for Untreated Eagle Ford Swell Data

	Moisture Content [%]	Compaction Void Ratio [ ]	Dry Density [pcf]
Minimum Value	23.0%	0.797	92.5
Maximum Value	24.8%	0.861	99.3
Percent Difference	8.0%	8.1%	7.3%

Figure 5-3. Centrifuge Test Stress-Swell Data for Untreated Eagle Ford Clay

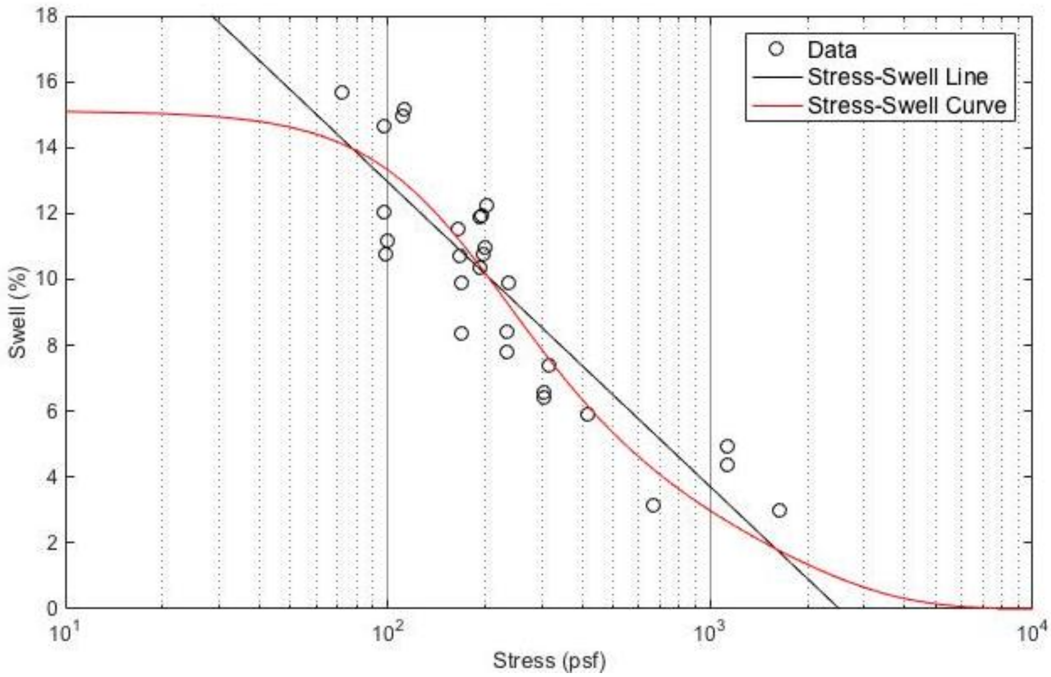


Figure 5-4. Best-Fit Curve and Best-Fit Line for Untreated Eagle Ford Clay

Table 5-4. R^2 Values for Untreated Eagle Ford Stress-Swell Curves

R^2 for 3-Parameter Curve	R^2 for Semi-log Line
0.8110	0.7894

It can be seen that, although the 3-parameter curve has a higher r^2 value, the data matches reasonably well with the stress-swell line, particularly in the stress range of 100 psf – 1000 psf that is most important to PVR calculation.

5.1.1. Effect of Water Content and Dry Density

Next, the effect of varying compaction moisture content and dry density were observed. Because expansive soils swell when introduced to free water, it can be expected that, other conditions staying constant, soil with a higher initial moisture content will swell less than soil that is compacted drier. It can also be expected that denser soils will swell more than less dense soils, other conditions staying constant. This is because denser soils 1) simply have more soil particles per unit volume, and thus more clay particles to absorb water, and 2) soils with more voids and less densely packed soil particles will have more room for the diffuse double layer of clay particles to expand without necessarily forcing all the surrounding particles to dilate as well.

Figure 5-5 plots the variation of swell with compaction moisture content for untreated Eagle Ford clay tested at an effective stress of approximately 95 psf (stress values vary from 90 psf – 99 psf). A linear trend can be seen between swell potential and decreasing moisture content. In fact, fitting the data to a straight line lends a slope of -1.1, showing that variation in moisture content has a nearly 1-to-1 correlation with variation in total swell potential (at this particular effective stress).

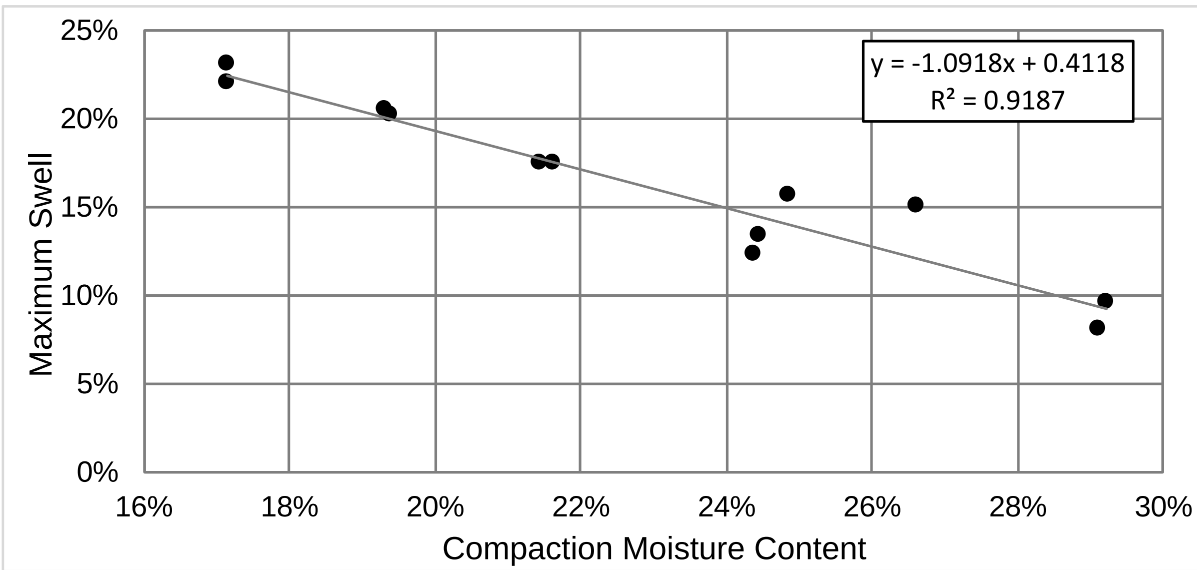


Figure 5-5. Variation of Swell with Compaction Moisture Content for Untreated Eagle Ford at 95 psf

Figure 5-6 plots the variation of swell with compaction dry density for untreated Eagle Ford clay tested at an effective stress of approximately 285 psf (stress values vary from 280 psf – 298 psf). Again, a linear trend can be seen between swell potential and increasing compaction dry density. When the data is fit to a straight line, a correlation can be found of an increase in swell potential of approximately 1% for an increase in dry density of 4 pcf (at this effective stress).

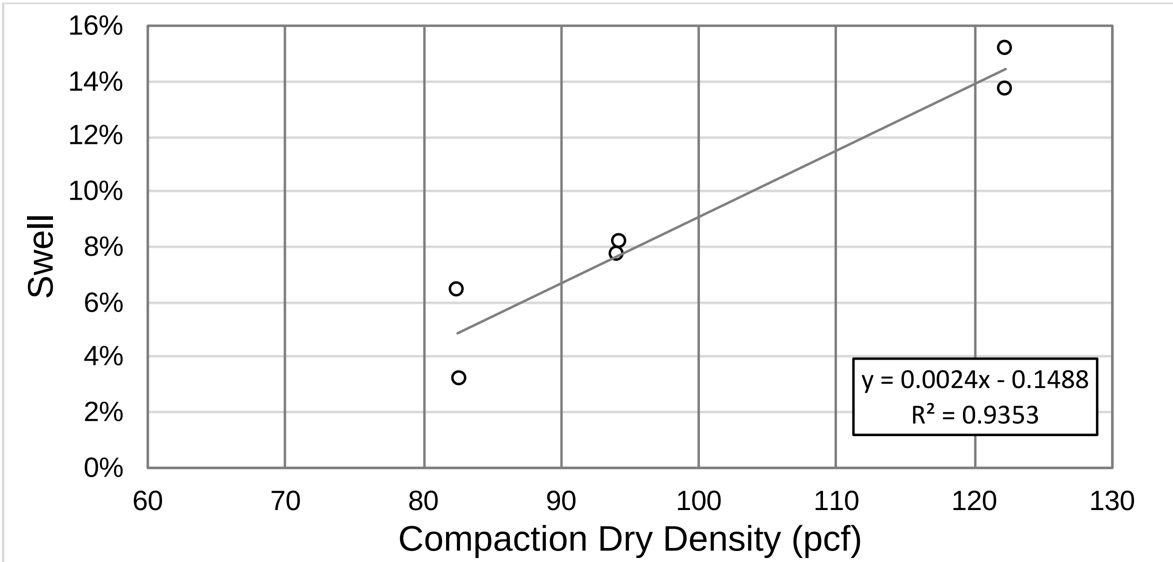


Figure 5-6. Variation of Swell with Dry Density for Untreated Eagle Ford at 285 psf

After assessing the effects of moisture content and dry density on the swell potential of the soil samples, the importance of comparing samples with nearly identical compaction conditions is apparent. For adequate test results, the initial moisture content range of comparable samples should vary by no more than 2%, and the compaction dry density should vary by no more than approximately 10% across the ranges tested.

5.2. Lime-Treated Test Results

Next, the effect of hydrated lime on otherwise comparable samples is observed. Table 5-5 shows the range of compaction conditions for the samples tested and shown in Figure 5-7, where swell potential is plotted against the amount by dry mass of hydrated lime added to each sample and tested at approximately 320 psf (stress values range from 309 – 337 psf).

The addition of hydrated lime significantly decreases the swell potential (from 8% to 3% swell with the addition of 1% lime). However, increasing the amount of lime added leads to diminishing returns after a certain point - after 3% lime is added to the soil, the swell potential for samples at the same effective stress hover between 0 – 1% for increasing amounts of lime.

Table 5-5. Range of Compaction Conditions for Lime-Treated Eagle Ford Swell Data

	Moisture Content [%]	Compaction Void Ratio [ ]	Dry Density [pcf]
Minimum Value	23.2%	0.793	93.6
Maximum Value	24.7%	0.844	95.5
Percent Difference	6.5%	6.5%	2.1%

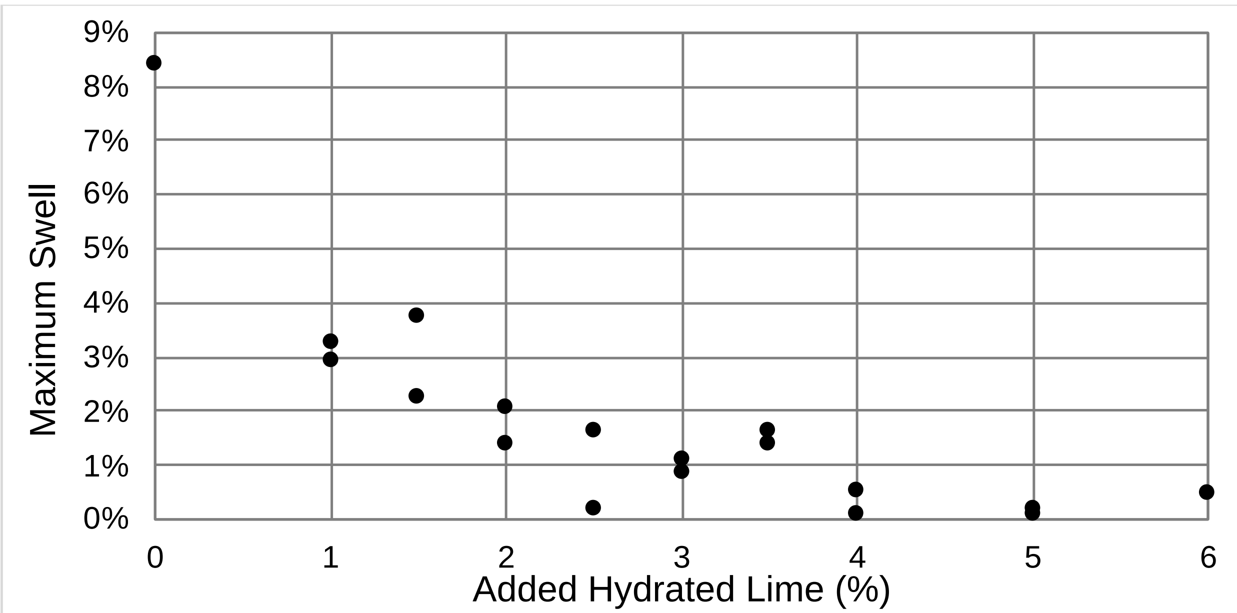


Figure 5-7. Variation of Swell with Percent Added Hydrated Lime for Eagle Ford at 300 psf

5.2.1. EAGLE FORD TREATED WITH 2% HYDRATED LIME

Next, to observe the stress-swell curves for lime-treated Eagle Ford, a set of tests were performed on soil treated with 2% hydrated lime. Table 5-6 shows the range of compaction conditions for samples tested and shown in Figure 5-8.

Table 5-6. Range of Compaction Conditions for 2% Lime-Treated Eagle Ford Swell Data

	Moisture Content [%]	Compaction Void Ratio [ ]	Dry Density [pcf]
Minimum Value	23.0%	0.785	93.7
Maximum Value	24.9%	0.833	96.7
Percent Difference	8.1%	6.2%	3.2%

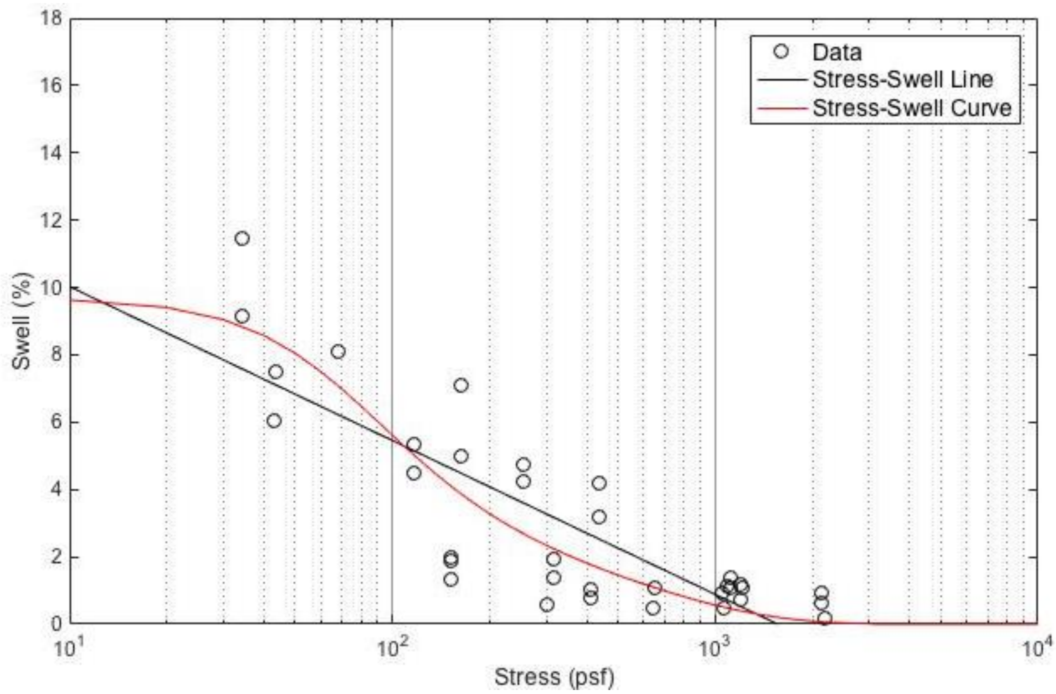


Figure 5-8. Best-Fit Curve and Best-Fit Line for Eagle Ford Clay Treated with 2% Hydrated Lime

The data still generally follows a log-linear curve; however, the lime-treated samples were found to generally exhibit more scatter than the untreated samples. This is likely due to heterogeneities from mixing lime into the soil. The soil is plotted with best fit curves for both the 3-parameter curve and a semi-log line, with r^2 values shown in Table 5-7.

Table 5-7. R^2 Values for Best-Fit Curves for 2% Lime Treated Eagle Ford

R^2 for 3-Parameter Curve	R^2 for Semi-log Line
0.7583	0.6943

5.2.2. EAGLE FORD TREATED WITH 4% HYDRATED LIME

A set of tests were also performed on Eagle Ford treated with 4% by mass hydrated lime. The range of compaction conditions for the samples tested are given in Table 5-8, and the stress-swell data is presented in Figure 5-9.

Table 5-8. Range of Compaction Conditions for 4% Lime-Treated Eagle Ford Swell Data

	Moisture Content [%]	**Compaction Void Ratio [ ]**	**Dry Density [pcf]**
Minimum Value	23.0%	0.792	89.6
Maximum Value	25.0%	0.911	95.7
Percent Difference	8.5%	15.1%	6.7%

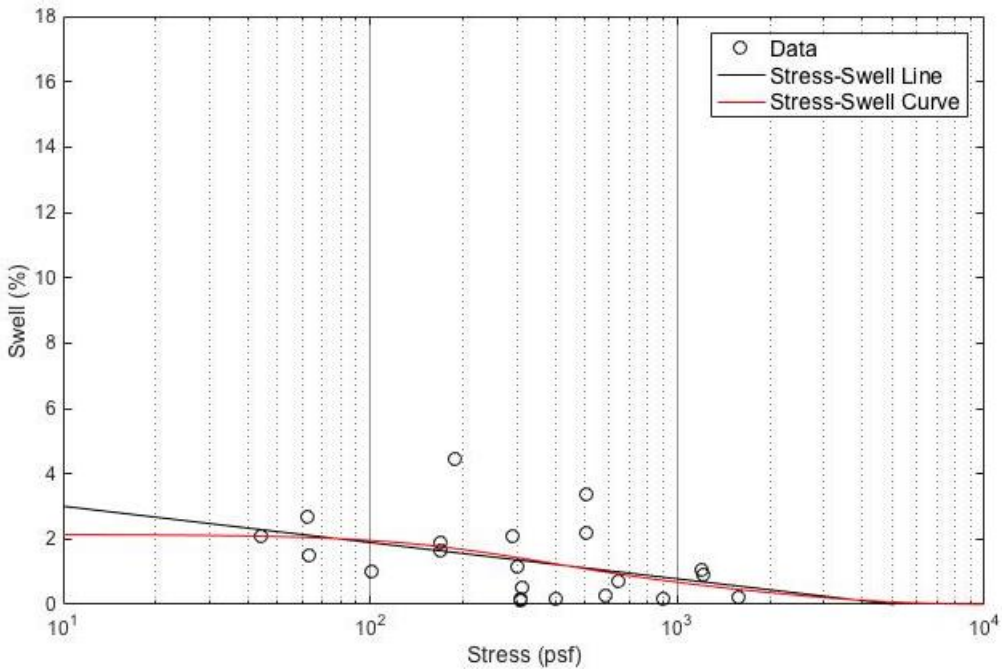


Figure 5-9. Best-Fit Curve and Best-Fit Line for Eagle Ford Clay Treated with 4% Hydrated Lime

As can be seen, this data exhibits more scatter than the untreated Eagle Ford samples but also swell significantly less. Generally, the samples treated with 4% lime swell no more than 3% - 4% regardless of effective stress and exhibit a range of approximately 2% swell at a given stress. For samples treated with enough hydrated lime to significantly decrease their swell potential, the 3-parameter curve appears to more closely approximate a semi-log line. In this case, the curves are effectively identical above effective stresses of approximately 50 psf. R^2 values for each of the curves are given in Table 5-9.

Table 5-9. R^2 Values for Best-Fit Curves for 4% Lime Treated Eagle Ford

R^2 for 3-Parameter Curve	R^2 for Semi-log Line
0.1789	0.1713

5.2.3. LIME-TREATED EAGLE FORD STRESS-SWELL CURVES

Figure 5-10 plots the aggregate stress-swell data for Eagle Ford at a range of lime additions. It can be seen that, despite some scatter, a trend of semi-log lines of decreasing slope with increasing lime additions is apparent.

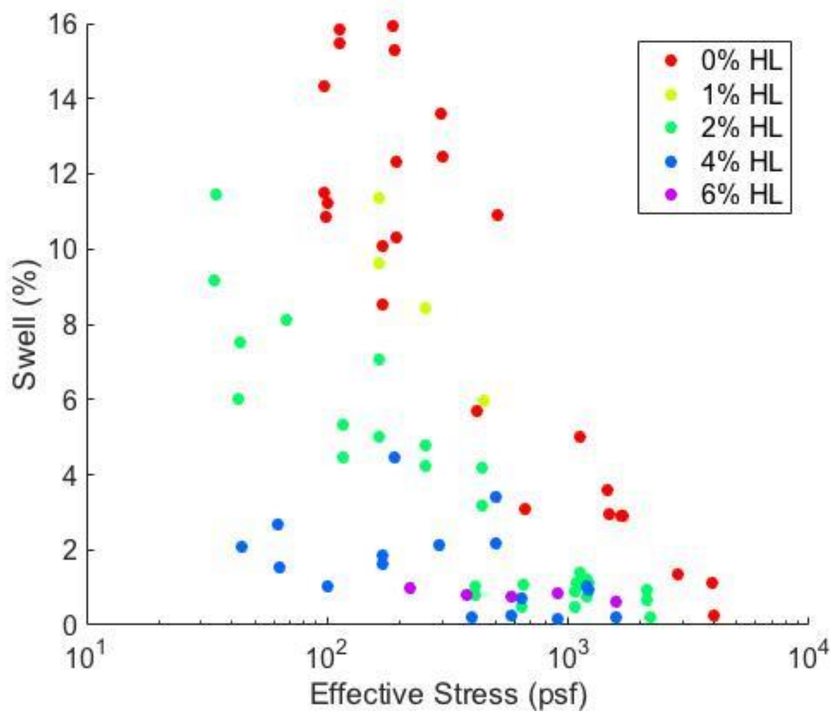


Figure 5-10. Stress-Swell Data for Untreated and Lime-Treated Eagle Ford Soil

5.3. Effect of Mellowing Time

Mellowing is a commonly adopted field approach that involves allowing a soil-lime mixture to rest for a period of time *before* compaction. Previous research has found that allowing soil to mellow for more than approximately 12 hours leads to a slight increase in swell (Belchior 2016). This is potentially because pozzolanic reactions begin to occur during the mellowing period and some of the soil beings to ‘cement” together, and then these soil bonds are effectively crushed during compaction, negating some of the effects of the lime. The effect of mellowing time was observed for Eagle Ford treated with 2% and 4% by mass of hydrated lime over a range of stresses. Samples were mixed and allowed to rest in sealed plastic bags before being compacted and tested in the centrifuge.

Figure 5-11 plots the effect of 2% lime-treated soil after mellowing for 1 day, 28 days, and 43 days. As can be seen, the effect of mellowing on soil with this amount of lime is not significant – the mellowed samples swell directly within the margin of error of the samples that were immediately mixed and tested. Figure 5-12 plots the effect of 4% lime-treated soil after mellowing for 1 day, 6 days, and 43 days. Again, there is not a noticeable effect on swell potential due to mellowing time, particularly within the inherent scatter of lime-treated soil samples. It can be concluded that while mellowing, as a field technique, is useful in facilitating soil workability, it does not provide significant benefits in determination of lime dosage.

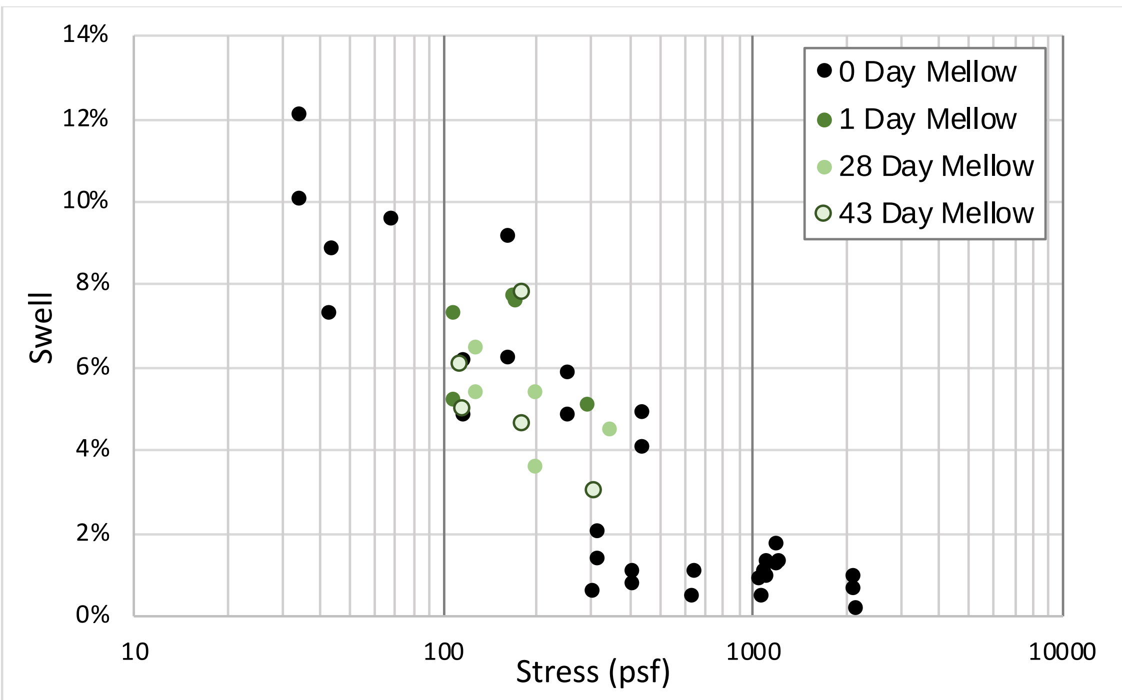


Figure 5-11. Variation in Mellowing Time for Eagle Ford Treated with 2% Hydrated Lime

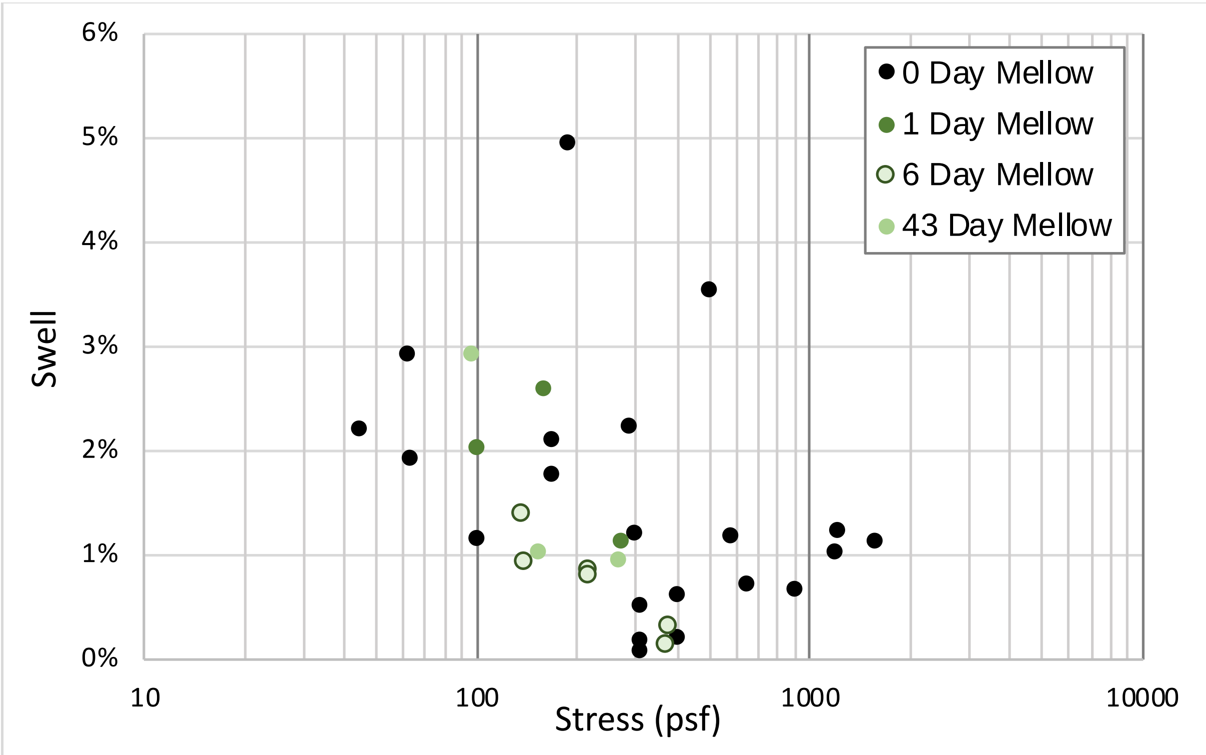


Figure 5-12. Variation in Mellowing Time for Eagle Ford Treated with 4% Hydrated Lime

5.4. Effect of Curing Time

Conversely, curing refers to the time that lime-treated soils are allowed to rest *after* being compacted. It is generally recommended that lime-treated soils be allowed to cure for at least 4 weeks to allow the pozzolanic reactions to fully occur, as this allows for a significant decrease in swell potential and an increase in compressive strength. However, these reactions may not fully occur if enough lime is not used. To observe the effect of curing, a series of stress-swell curves were created for Eagle Ford treated with 2% and 4% hydrated lime. Samples were compacted in a 2.5-inch cutting ring and allowed to cure in a wet room for the prescribed amount of time. At the time of testing, samples were trimmed to fit in the 2-inch cutting rings and tested in the centrifuge.

Figure 5-13 plots the stress-swell curves for 2% lime-treated Eagle Ford after curing for 14, 21, and 56 days. As can be seen, no significant decrease in swell occurs in the cured samples of 2% lime-treated Eagle Ford. This is likely because 2% is insufficient for properly activating the pozzolanic reactions in the highly plastic Eagle Ford soil.

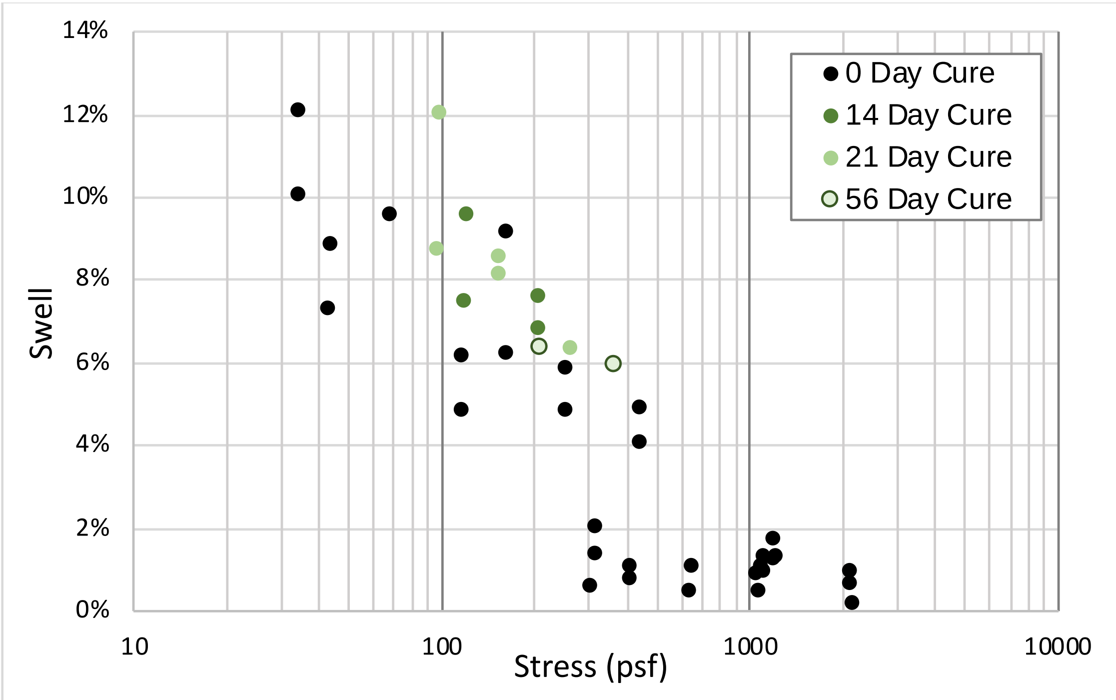


Figure 5-13. Variation in Curing Time for Eagle Ford Treated with 2% Hydrated Lime

Figure 5-14 plots the stress-swell curves for 4% lime-treated Eagle Ford after curing for 42 and 56 days. In this case, the increased curing time almost completely negates any swell potential in the samples. It is apparent that the Eagle Ford soil requires close to 4% hydrated lime to fully activate the pozzolanic reactions between lime and soil. However, it is unlikely that standard testing schedules will allow for samples to cure for 4-6 weeks before testing, so it is likely not an efficient use of time to prepare many cured samples for testing lime-treated soil samples. Additionally, soil strength is not likely to be of critical importance in transportation and pavement projects due to the low stresses that the soils are generally subjected to.

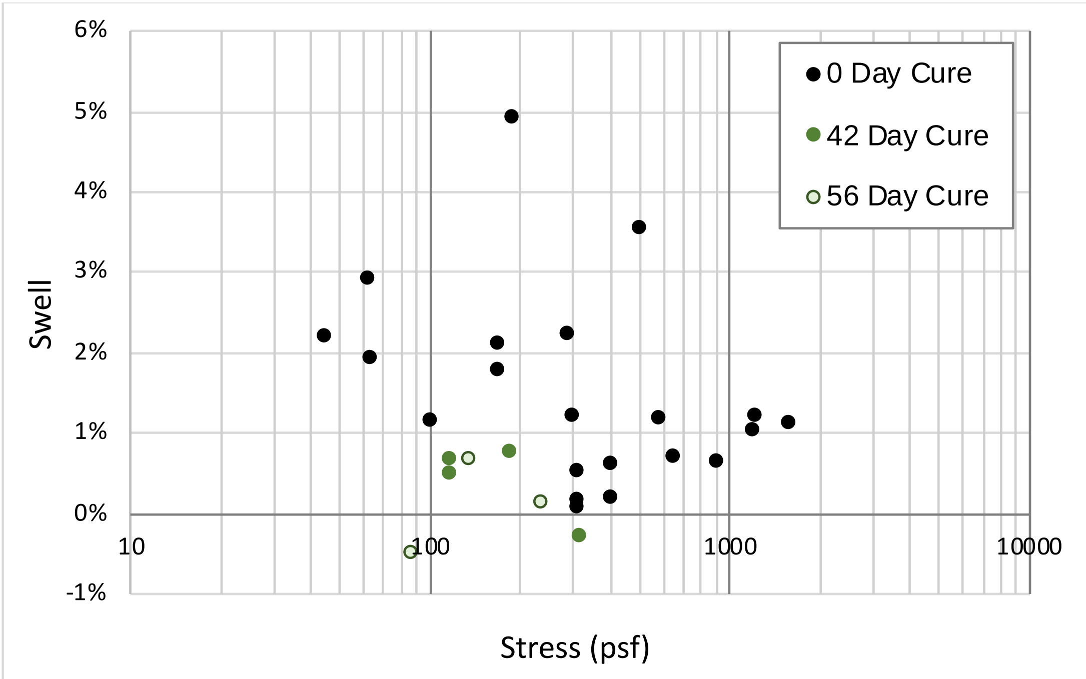


Figure 5-14. Variation in Curing Time for Eagle Ford Treated with 4% Hydrated Lime

5.5. Swell Pressure Results

To better compare the effect of lime treatment on swell pressure, a free swell test was performed on Eagle Ford treated with 4% hydrated lime. The test was prepared in accordance with ASTM D4546 Method C, also called the *loading after wetting* test method. In this method, the sample was inundated and allowed to swell under a stress of 250 psf. After swelling, the load on the sample is increased, similar to a standard consolidation test, and the load-induced strains are measured. The swell pressure is determined as the pressure required to revert the sample to its initial height.

Figure 5-15 first compares the swell potential of this sample to other samples of Eagle Ford treated with 4% lime and compacted at similar initial conditions. As can be seen, the free swell data matches well with centrifuge swell data for this case.

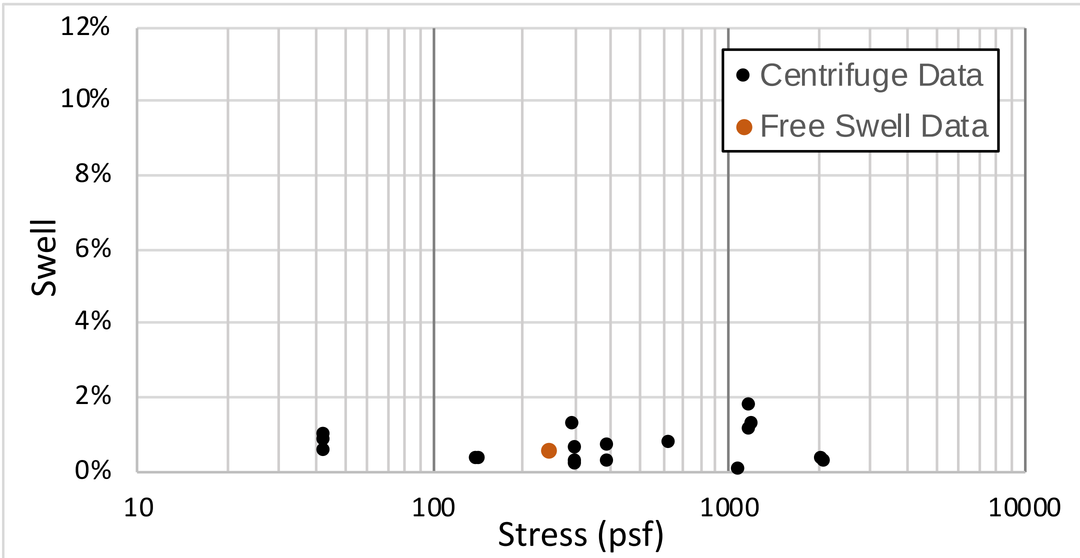


Figure 5-15. Comparison of Centrifuge and Free Swell Test Results for Eagle Ford Treated with 4% Hydrated Lime

Figure 5-16 plots the results of the swell-consolidation test. The sample has a generally linear decrease in swell with an increase in applied stress, and a "swell pressure" of approximately 2100 psf can be observed from the data.

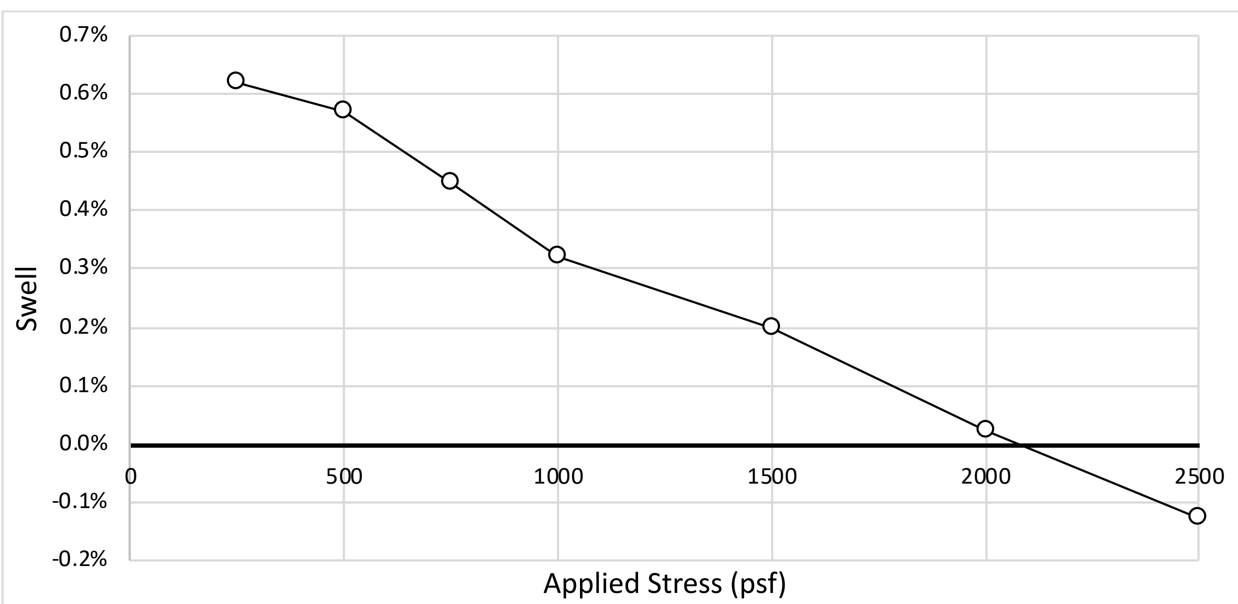


Figure 5-16. Swell-Consolidation Test Results for Eagle Ford Treated with 4% Hydrated Lime

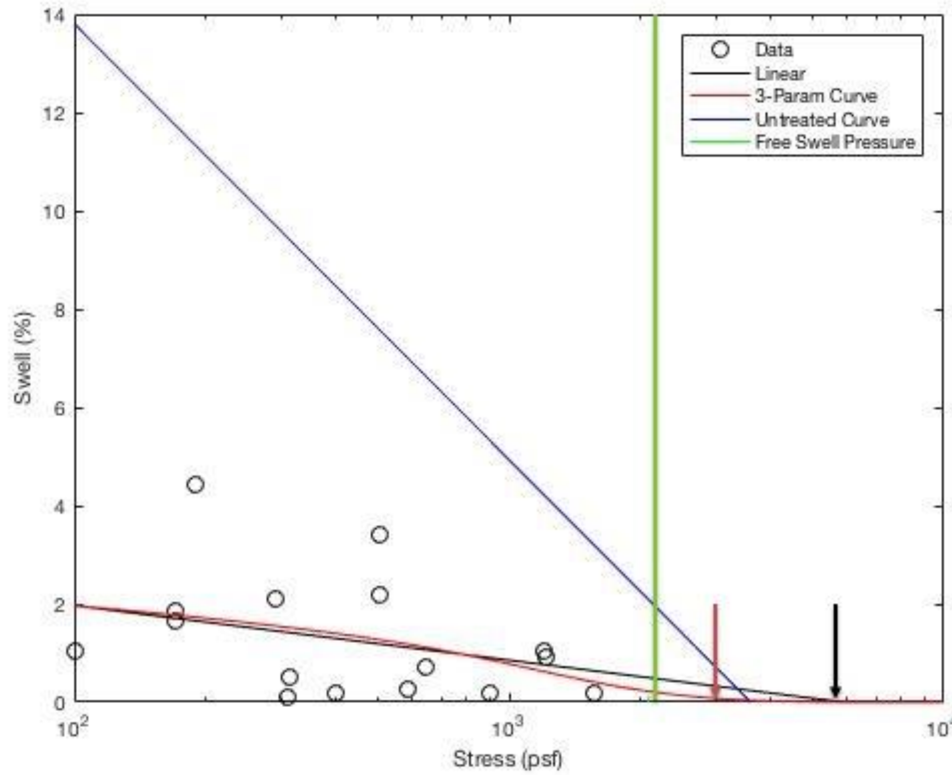


Figure 5-17. Comparison of Swell Pressure Values for 4% Lime-Treated Eagle Ford from Graphical Methods

This swell pressure is compared to swell pressures determined graphically from a series of other methods: from the 3-parameter curve fit to the 4% lime centrifuge data, from the semi-log line fit to the 4% lime centrifuge data, and from the extrapolated swell pressure of the semi-log line fit to the untreated Eagle Ford data. The data is shown graphically in Figure 5-17 and tabulated in Table 5-10.

Table 5-10. Comparison of Swell Pressure Values for 4% Lime-Treated Eagle Ford from Graphical Methods

Free Swell Pressure [psf]	3-Parameter Curve Swell Pressure [psf]	Semi-log Linear Swell Pressure [psf]	Untreated Semi-Log Linear Swell Pressure [psf]
2100	3000	5500	3500

5.6. Test Procedure Recommendations

For the centrifuge testing program, it is not recommended that soil samples be cured before testing for swell potential. While a decrease in swell may occur after curing with enough lime, the amount of time necessary for curing samples is not conducive to rapidly testing samples and producing swell test results. Because mellowing does not appear to significantly affect the amount of swell potential and because allowing the soil to mellow for approximately 24 hours produces a more homogenous and friable mixture, it is recommended that the moisture conditioned soil-lime mixture be prepared and allowed to rest for 12-24 hours before testing.

6. NEW METHODOLOGY FOR OPTIMIZATION OF LIME TREATMENT

This chapter covers the equipment and methodology recommended for optimization of testing soil samples to determine untreated and lime-treated PVR. For a given location, it is recommended that soil samples be taken at 2-ft intervals to a depth of 10 ft for accurate PVR determination. This recommendation is consistent with testing procedures from TxDOT Tex-124-E testing procedures. Because the majority of the swell potential occurs in the top few feet of soil, samples may be taken to a depth of 6 ft if it can be reasonably determined that the soil profile below is very similar to the soil already retrieved. For the purposes of using the PVR calculation spreadsheet, a soil stratum should extend to a depth of 10 ft and be separated into 3-4 layers.

6.1. Materials and Equipment

The following subsections list and describe the necessary materials and equipment for properly performing a swell test in the centrifuge.

6.1.1. APPARATUS

- *Hydraulic Centrifuge*, capable of reaching accelerations of at least 250 G's and with space to test 6 concurrent samples. Centrifuge should be outfitted with in-flight data acquisition system and linear position sensors to continuously monitor sample height during testing.
- *Metal Centrifuge Buckets*, 6.
- *Centrifuge Permeameter Cups with Threaded Lid*, 6. Cups should fit snugly into centrifuge buckets, and permeameter material should have a Young's Modulus exceeding 71×10^3 psi (e.g., acrylic).
- *Cutting Rings, 2" diameter,* 6. Rings should fit snugly into permeameter cups.

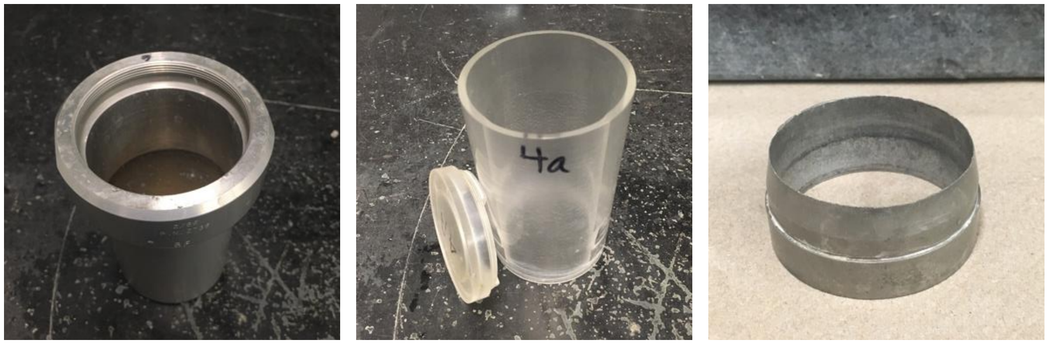


Figure 6-1. From left to right: Metal Centrifuge Bucket, Permeameter Cup, and Cutting Ring used in Centrifuge Testing

- *Filter Paper,* 12 sheets, trimmed to 2” diameter circles.
- *Brass Porous Discs*, 6, 0.1” thickness and 2” diameter.
- *Brass Porous Discs*, *6*, 0.1” – 0.4” thickness and 2” diameter. It is recommended that, for swell testing untreated soil samples, 2 of each height of porous disc be used, and when swell testing lime-treated soil samples, the 0.2” porous discs be used.

Figure 6-2. Left to Right: 0.1”, 0.2”, 0.4” Brass Porous Discs

- *Compaction weight*
- *Rubber mallet*
- *Small kneading compaction hammer*
- *Syringes*, 6, 100 mL capacity.
- *Bowl*
- *Spray Bottle*, at least 250 mL capacity.
- *Metal spatula*
- *Moisture Content Trays*
- *Balance,* capable of reading to 0.01g up to 1,000g.

- *Vertical Caliper*, capable of reading 0.001” up to 2.000”.
- *Drying Oven*, capable of continuously heating at 110 +/- 5 °C.

6.1.2. **Materials**

- *~250g air-dried, processed soil for each set of 6 samples*
- *Hydrated Lime*
- *Water*

6.2. Determining Initial Conditions

The centrifuge PVR methodology requires that samples be compacted to similar relative compactions and moisture contents for comparison purposes. This target condition is identified as 100% of the relative compaction at a moisture content of 3% below optimum from a Standard Proctor test. Because there may not be enough time or available soil to conduct a Standard Proctor Test for each soil depth, the target densities and moisture contents may be based on correlations with the Atterberg limits, as determined by USACOE Correlations documented in the Construction Control for Earth and Rock-Fill Dams Engineering Manual (USACE, 1995). The correlations for optimum moisture content and maximum dry density are shown in Equations 6-1, 6-2, and 6-3:

$$w_{opt} = 0.24LL + 7.349 \qquad Eq.6-1$$

$$\gamma_{d,max} = -0.414LL + 123.704\ (pcf) \qquad Eq.6-2$$

$$w_{target} = w_{opt} - 3\% \qquad Eq.6-3$$

Air-dried, processed soil should be mixed to the target moisture content and allowed to rest for 12-24 hours before measuring moisture content. Equation 6-4 can be used to easily calculate the required amount of water to add to the air-dried soil to reach the target moisture content:

$$m_{w,req} = \frac{m\left(w_{target} - w_{AD}\right)}{1 + w_{AD}} \qquad Eq.6-4$$

For preparing lime-treated soil, the mass of hydrated lime is added as a percentage of the mass of soil solids and can be calculated using Equation 6-5:

$$m_{HL} = \frac{HL_{target} * m}{1 + w_{AD}} \qquad Eq.6-5$$

As previously discussed, air-dry soil should be mixed with the appropriate amount of lime before moisture conditioning, to allow for a more homogenous mixture. Because the hydrated lime increases the mass of solids, more water will be required for mixing lime-treated soil to the same moisture content as untreated soil. Equation 6-6 may be used to determine the required amount of water for moisture conditioning:

$$m_{w,req} = \frac{m\left(w_{target} - w_{AD}\right)}{1 + w_{AD}} + w_{target} m_{HL} \qquad Eq. 6-6$$

As with untreated moisture-conditioned soil, lime-treated moisture-conditioned soil should be allowed to rest for 12-24 hours before measuring moisture content.

6.3. Compaction and Preparation of Test Samples

Given the target dry density (in pcf) and moisture content (as a decimal) of the samples, the required mass of soil for each sample may be calculated using Equation 6-7. The target height of each sample is 1.00 cm (0.394 in), and sample cutting rings are 5.08 cm (2 in) in diameter, for a sample volume of 20.27 cm^2.

$$m_{req} = \gamma_{d,max}\left(1 + w_{target}\right) * \frac{1 \, {}^{g}/_{cm^3}}{62.4\, pcf} * 20.27 cm^2 \qquad Eq. 6-7$$

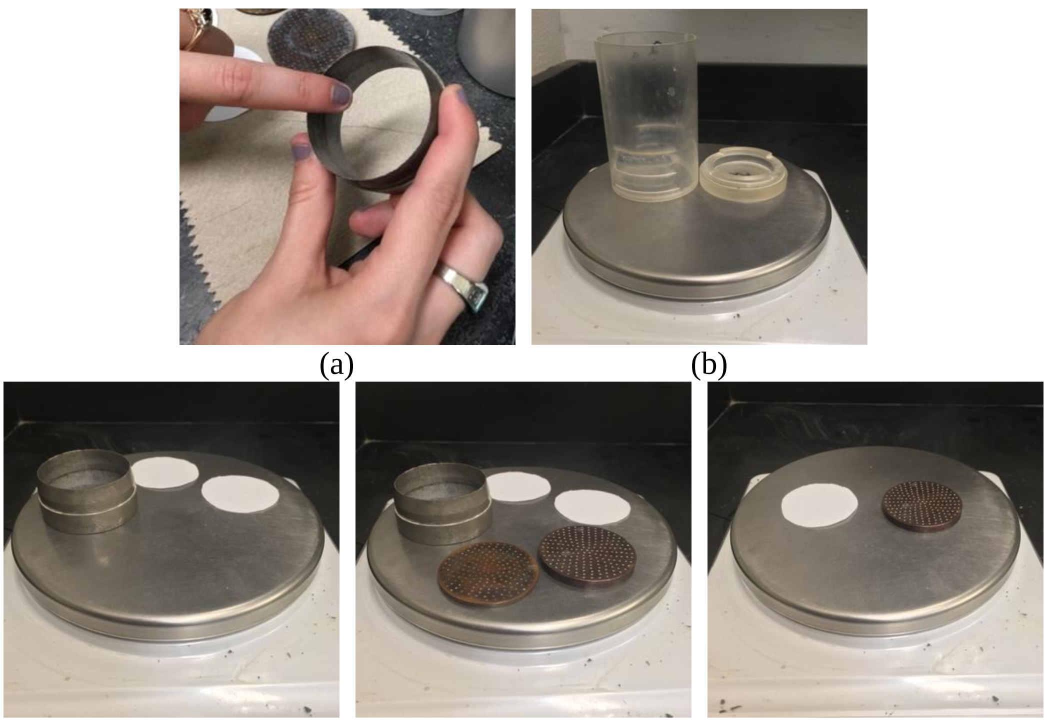
Next, a target G-level should be chosen such that an effective stress close to the average stress on each sample at depth will be imposed. Table 6-1 provides G-level recommendations to reach associated stress ranges. These values assume the use of a centrifuge with a rotor arm of similar length to that currently used by The University of Texas and assume the use of the 3-aforementioned brass porous discs to impart an overburden stress.

Table 6-1. Centrifuge G-Level Recommendations for Target Stress Ranges

Depth [ft]	Approximate Stress at Depth [psf]	G-Level [G's]	Tested Stress Range [psf]
0' – 2'	175 – 400	20	150 – 300
2' – 4'	400 – 625	35	200 – 550
4' – 6'	625 – 850	55	300 – 850
6' – 8'	850 – 1075	70	400 – 1100
8' – 10'	1075 – 1300	85	500 – 1300

When performing a centrifuge test for 6 untreated samples, 2 porous discs each of 3 different weights should be used to produce a stress-swell curve. When performing a centrifuge test on lime-treated samples, it is only necessary to use one type of porous disc, as the method only requires one data point per lime dosage per depth. It is recommended that, for a test of 6 samples, 2 samples each of 3 different lime dosages be tested at each depth. It has been observed in the range of samples tested that dosages of 4%, 5%, and 6% by dry mass of hydrated lime will very significantly decrease (or almost completely negate) the swell potential of most expansive soils.

Top and bottom filter papers for each sample should be trimmed such that they fit snugly inside the cutting ring. Each cutting ring should be greased sparingly with vacuum grease to reduce the side friction on the samples, but there should not be an excess of grease on the rings. Per the test data sheet, weigh and record masses of: permeameter cup, cutting ring with filter paper, cutting ring with filter paper and top and bottom porous discs, and top porous disc with top filter paper, as shown in Figure 6-3.



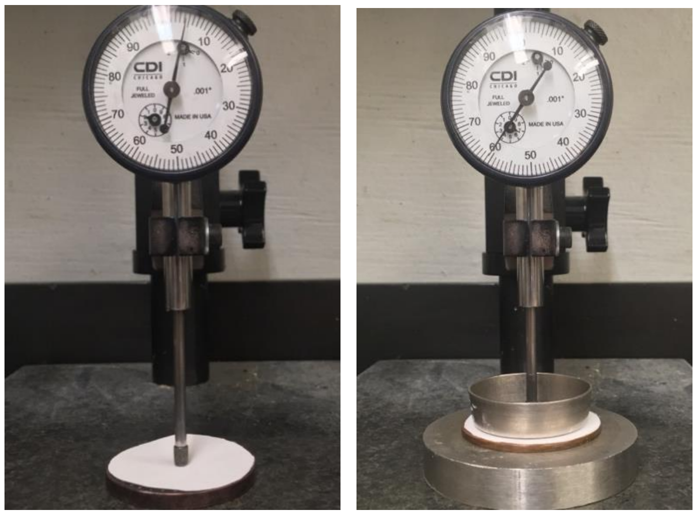
(a) (b)

(c) (d) (e)

Figure 6-3. (a) Applying Vacuum Grease to Cutting Rings, (b) Weighing Permeameter, (c) Weighing Cutting Ring and Filter Paper, (d) Weighing Ring, Filter Paper, and Porous Discs, (e) Weighing Top Filter Paper and Porous Disc

Next, the height of the top porous disc and filter paper and the height of the sample base should be measured using a vertical dial indicator, as shown in Figure 6-4. It is important to measure the bottom height using the base plate and top leveling plate, as this height measurement will be used to determine the height of the compacted soil. The target height of soil may be calculated as:

$$target\ height = bottom\ height + 0.394''$$



(a) (b)

Figure 6-4. (a) Measuring Height of Top Disc and Filter Paper, (b) Measuring Base Height

After the bottom porous disc and filter paper are placed inside the cutting ring, the target mass of soil should be added and recorded. The current compaction method is shown in Figure 6-5 and described as follows:

(a) Soil may be lightly compacted with thumb to produce an even surface for compaction and to ensure all soil is placed in cutting ring.

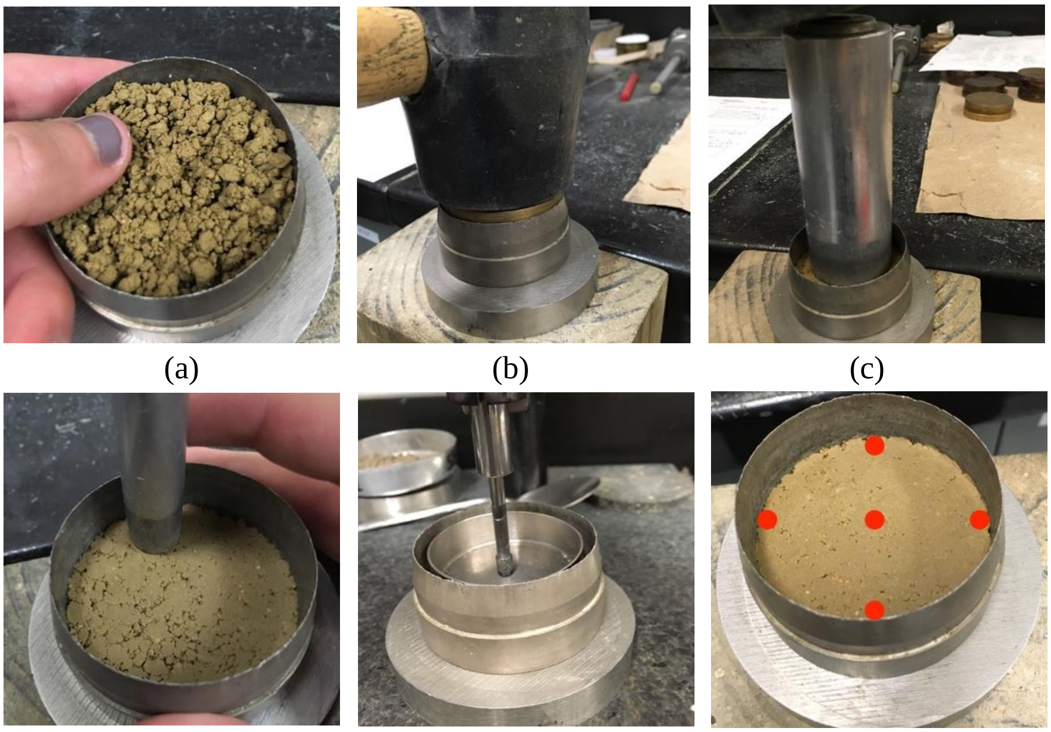
(b) Sample is first compacting using a 2-inch diameter disc and rubber mallet such that sample is evenly compacted, and large differential heights are minimized.

(c) Sample is then compacted using compaction weight and rubber mallet.

(d) Final compaction adjustments may be made with small compaction hammer and/or compaction weight to ensure constant height and even top surface of the sample.

(e) Sample height is monitored regularly through compaction process using vertical dial indicator and top leveling plate.

(f) After sample is compacted to within 0.005” of target, height is measured and recorded in the center and 4 corners of the sample.

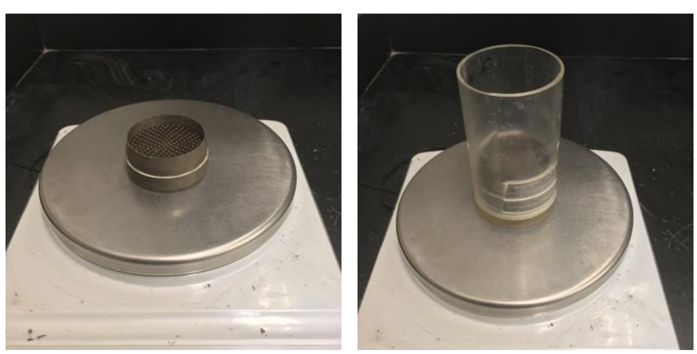


(a) (b) (c)

(d) (e) (f)

Figure 6-5. Compaction Process for Centrifuge Test Samples

After compaction, the top filter paper and porous disc are placed over the sample. The sample is weighed and then placed inside the permeameter and weighed.



(a) (b)

Figure 6-6. (a) Weighing Prepared Sample, (b) Weighing Sample in Permeameter

To ensure that centrifuge is balanced, each total apparatus (permeameter and centrifuge bucket) should be weighed, as shown in Figure 6-7, and the total mass should be compared between each paired sample (1 and 2, 3 and 4, 5 and 6). Paired samples should have the same total mass within approximately 5 grams. If the difference in mass exceeds this, the lighter of the two should be augmented with foil or metal washers at the bottom of the centrifuge bucket. The mass of each empty centrifuge bucket should be measured and recorded, then the permeameters may be placed inside and set up in the centrifuge.

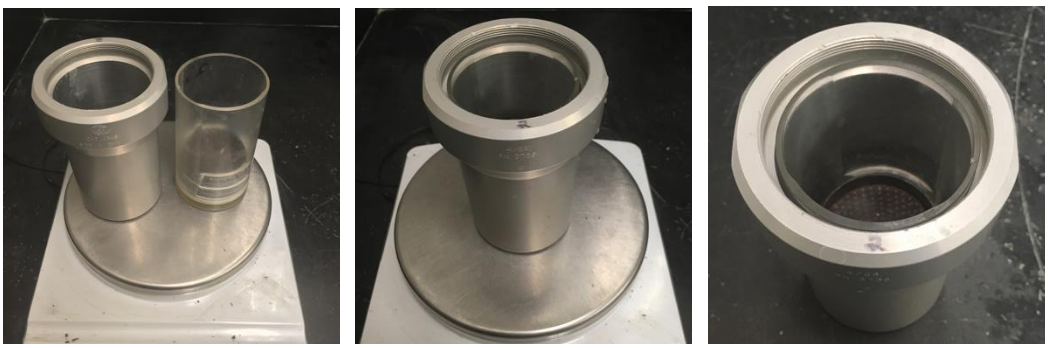


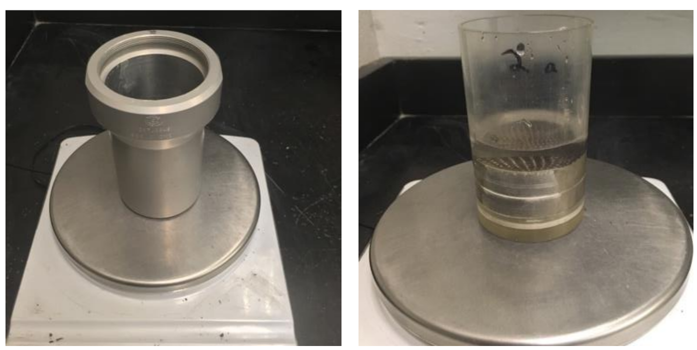
Figure 6-7. (a) Weighing Total Apparatus, (b) Weighing Centrifuge Bucket, (c) Placing Permeameter in Centrifuge Bucket

Each apparatus should be placed in its corresponding centrifuge arm, as shown in Figure 6-8, with the lid properly secured. Ensure that wires are free and that both the lid and linear position sensor are fit snugly, to minimize any shaking during testing that may affect the LPS.

Figure 6-8. Prepared Buckets Arranged in Centrifuge with LPS Lids Secured

After the centrifuge is loaded, the data acquisition system and then the centrifuge should be started. The samples should be allowed to compress under a seating load of 3-5 G's for approximately 5 minutes before compressing at the target G-level for approximately 1 hour or until sample heights stabilize. After this, the centrifuge should be stopped, and each sample should have 100 mL water added via syringe through the small hole at the top of each centrifuge lid. This step should be performed expeditiously such that any 1-G swelling is minimized. The samples will then swell under the target G-level for 24-72 hours or until samples are well into the "secondary swell" stage (have reached a relatively constant height) such that this section of the swell-time plot will be visible on a logarithmic scale.

Once test has run to completion, the data acquisition system and centrifuge should be stopped, and the centrifuge buckets should be removed immediately. It is important that the final steps of the test be performed quickly to minimize additional water intake by the samples after the centrifuge-imposed stresses are removed. The mass of the total apparatus (Figure 6-9a) should be measured and recorded, then the permeameter should be removed and its mass measured, after any excess water has been wiped from the outside (Figure 6-9b).



(a) (b)

Figure 6-9. (a) Weighing Apparatus After Test, (b) Weighing Permeameter After Test

After weighing the permeameter, all excess water should be poured out and the soil ring should be removed. The top and bottom porous discs should then be removed, and any excess water should be wiped from the ring and filter paper, such that the measured final moisture content is not affected by extraneous water. Moisture content values should be measured and recorded for each sample post-swelling. These values will also be used to back-calculate the compaction moisture content for each sample.

(a) (b)

Figure 6-10. (a) Moisture Content Tray, (b) Weighing Wet Sample with Filter Paper

6.4. Test Analysis Procedure

First, the centrifuge test data must be analyzed to produce the necessary stress-swell data for the PVR calculation spreadsheet. All data recorded during preparation should be input into the Centrifuge Test Data Template spreadsheet, and the swell data from the data acquisition system should be uploaded to the spreadsheet. Figure 6-11 shows a section of the Data Input sheet; the swell data is input on the left-hand side, and time values for determining the seating height, initial height, and start of swell are input in the pink shaded boxes on the right-hand side. The seating height is taken as the sample height during the seating load of 3-5 G's, and the initial height is taken as the height near the end of the compression stage when sample heights have stabilized.

dT (hr)	dS1 (cm)	dS2 (cm)	dS3 (cm)	dS4 (cm)	dS5 (cm)	dS6 (cm)	g-level	Adjusted Time	Row Number
								-1.74	2
								-1.72	3
								-1.70	4
								-1.68	5
								-1.66	6
								-1.64	7
								-1.62	8
								-1.60	9
								-1.58	10
								-1.57	11
								-1.55	12
								-1.53	13
								-1.51	14
								-1.49	15
								-1.47	16
								-1.45	17
								-1.43	18
								-1.41	19
								-1.39	20

Instructions for Inputting Data	
1	Import Data from processed text file
2	Start import at Row 2
3	Select "Comma" Delimited
4	Leave cell formatting "General"
5	Before Inserting Data, Click on "Properties"
6	Deselect "Save Query Definition"
7	Select "Overwrite Existing Cells, delete Unused Cells"
8	Import Data to Cell A2, and fill in Cells for 'Adjusted Time' and 'Row Number'
9	Enter the Row Number corresponding to the Seating Load, Initial, and Begin of Swell
10	Use Graphs for reference when selecting row numbers

	Enter Row #	Time (hr)	S1 (cm)	S2 (cm)	S3 (cm)	S4 (cm)	S5 (cm)	S6 (cm)
Seating:	3.00	0.02	-0.01	0.00	-0.01	-0.01	-0.01	-0.01
Initial:	92.00	1.74	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01
Begin of Swell:	92.00	1.74						

Target G - Level:	20
Actual G - Level:	22.11

Values to Plot for Visual Checks			
9.94	-1.72	-0.02	0.00
-0.28	-1.72	0.00	0.00

Figure 6-11. Data Input Sheet in Centrifuge Test Data Template

Figure 6-12 shows the initial compression data for each sample and the point of measurement for seating and initial heights. Figure 6-13 shows the swelling curves for each sample after the water has been added and the swell test has begun. It can be seen that the samples reach the end of primary swell within approximately 4 hours, but the samples are allowed to swell for a total of 16 hours to ensure that they are well into the secondary swell stage.

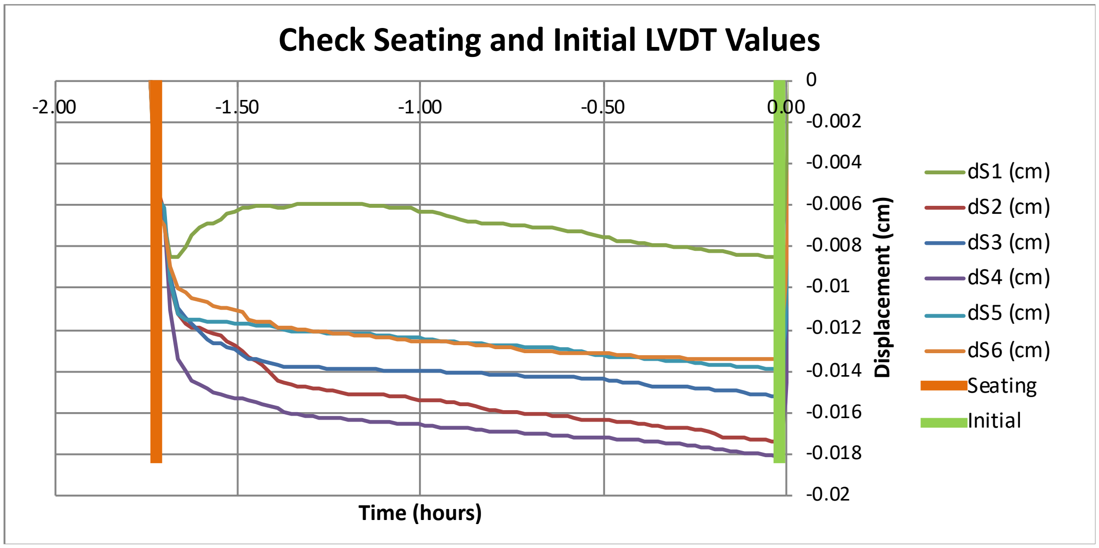


Figure 6-12. Determining Seating and Initial Height Values

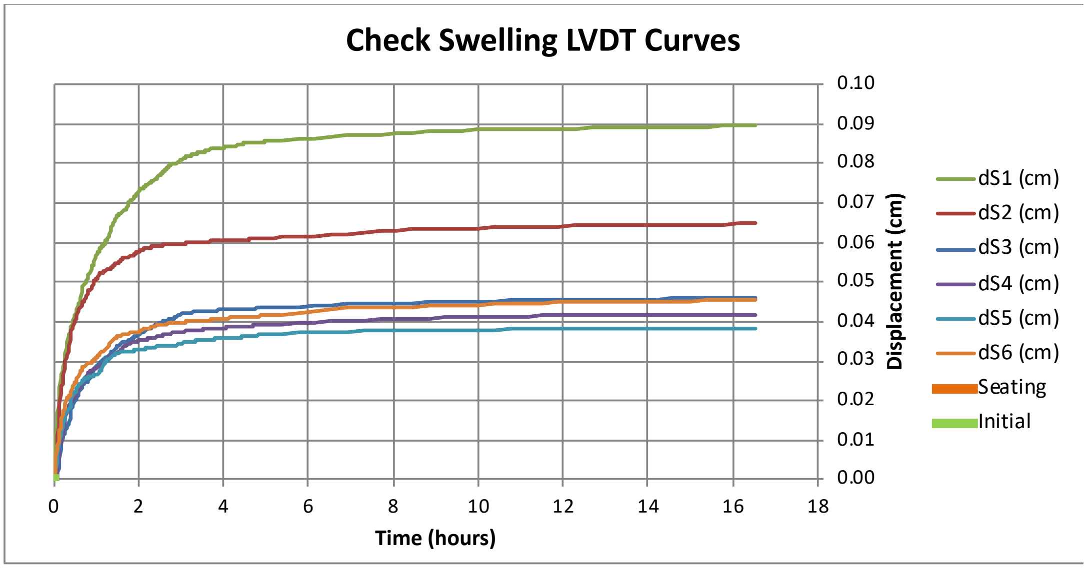


Figure 6-13. Sample Time-Swell Curves from Centrifuge Data

Figures 6-14 and 6-15 show the swell-time curve for a sample in semi log space, along with representative points for both primary and secondary swell. The point representing the end of primary swell is shown in yellow in Figure 6-15 and is determined as the intersection of the lines created by the red points and the green points in Figure 6-15. These points are determined by adjusting the time values in yellow in Figure 6-14 such that the first two points are within the area of primary swell, and the second two points are within the area of secondary swell.

	Sample Height	Swelling	Time	Slope (ln)	Slope(log)
Primary	1.01496704	3.25%	9.28	1.97%	4.53%
	1.065290712	8.36%	125.32		-0.01
Sec.	1.076681296	9.52%	269.27	0.35%	0.80%
	1.08062405	9.92%	853.49		0.08

Figure 6-14. Determining Slope of Primary and Secondary Swell Curves

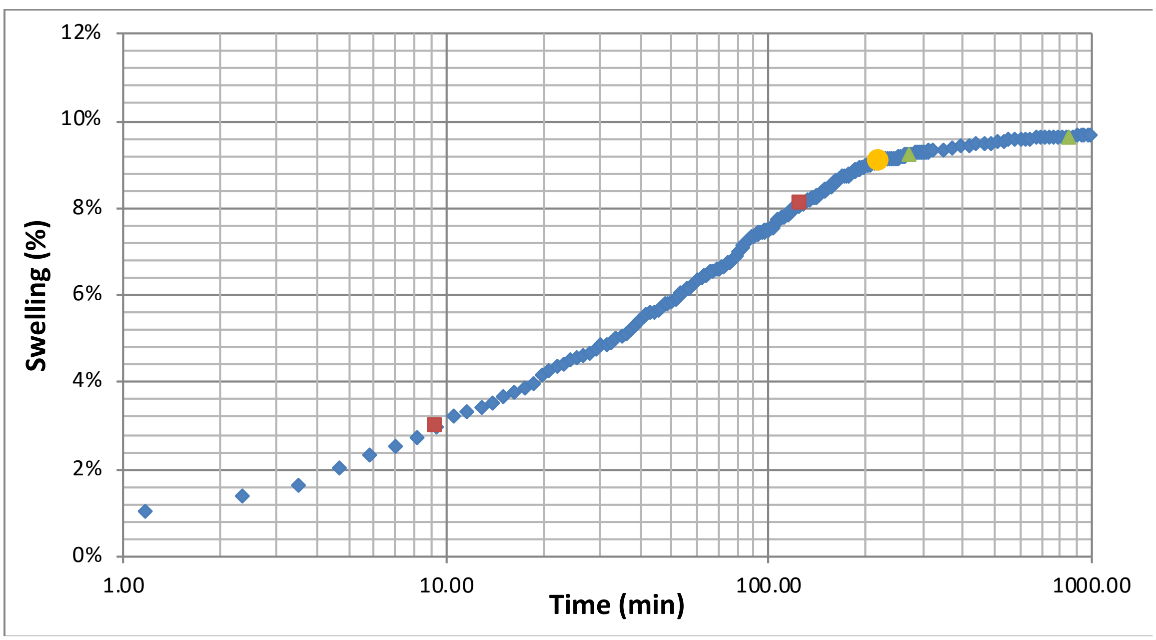


Figure 6-15. Sample Time-Swell Curve in Semi-Log Space to Determine End of Primary Swell

Repeating this process with each of the samples will produce a stress-swell curve, as shown in Figure 6-16. The “swell” values shown are the swell values at the end of primary swell, as determined using the above method. The “max swell” values are the maximum values determined across the swell-time curve. The stress-swell data shown here is then used in the PVR Calculation Spreadsheet.

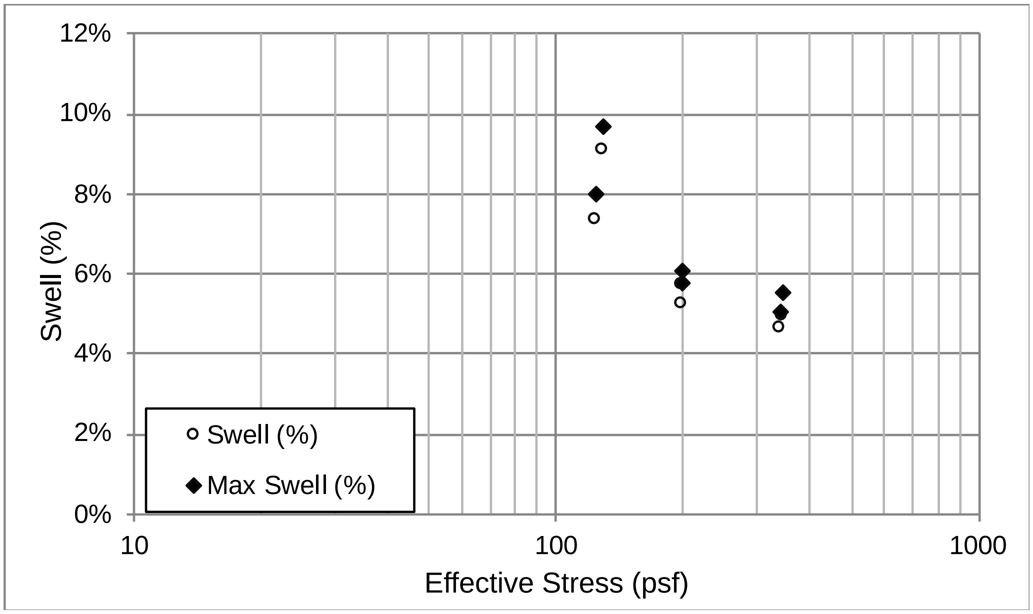


Figure 6-16. Sample Stress-Swell Centrifuge Data

First, index parameters for the pavement and overburden must be input into the spreadsheet, shown in Figure 6-17. This includes the thickness and unit weight of the pavement, base, and top soil that overlay the expansive subgrade.

Pavement and Overburden Inputs

$H_{,pavement}$=	4	in	H,base=	10	in	H,top soil=	0	ft	County:		Date Sampled:	
$\gamma_{,p}$=	145	pcf	$\gamma_{,b}$=	150	pcf	$\gamma_{,x}$=	100	pcf	Highway:		Ground El:	
$\sigma_{,bp}$=	48	psf	$\sigma_{,b}$=	125	psf	σ,ts=	0	psf	CSJ Number:		Station:	
$\sigma_{,load}$=	0	psf							District:		Offset:	
$\sigma_{,top}$=	173	psf							Boring No:	B-02		

Figure 6-17. PVR Calculation Spreadsheet Inputs for Pavement and Overburden

Next, soil properties and stress-swell data are input into the spreadsheet for each soil layer. Figure 6-18 shows examples of soil input properties for a given layer of untreated (a) and lime-treated (b) soil. For each layer, the soil type, liquid limit, plasticity index, percent soil binder (percent passing the No. 40 sieve), and layer thickness should be input. The target moisture content, dry density, and bulk density will be calculated automatically. For the untreated soil PVR, stress-swell data as previously determined should be input in the appropriate shaded boxes in Figure 6-18a. The Solver function in Excel can then be used to determine the fitting coefficients A and B by minimizing the RMSE. The swell pressure is calculated using the fitting coefficients as the stress value where the best-fit line crosses the x-axis (where the swell potential reaches zero). The untreated stress-swell data and best-fit line are shown by the solid line in Figure 6-19.

Next, the data points for a prescribed lime dosage are input into the appropriate shaded boxes in Figure 6-18b. The spreadsheet uses these points and the calculated swell pressure to fit a semi-log linear curve through the data. Again, the Solver function is used to determine the coefficients A and B by minimizing the RMSE for the lime-treated inputs. This data and best-fit line are shown by the dotted line in Figure 6-19. The treatment depth can be adjusted in the appropriate shaded box in Figure 6-18b, which allows the user to easily vary the depth of lime treatment and observe the change in PVR.

Expansive Deposits Inputs

Layer 1

Soil	HB	-
LL	81	%
PI	55	%
% -No.40	100	%
ω=	24%	%
γ_d=	90	pcf
γ=	112	pcf
Thickness	4.0	ft

Note: Correlations for ω_{opt} and γ_d are from USACOE 1995

A	-0.077	RMSE:	9.80E-03
B	0.2375	r^2:	0.6594

"Swell Pressure": 1174 psf

Semi Log-Linear: y = Alog10(x) + B

Equiv. Stress (psf)	Swell (%)	Swell, Predicted (%)	Error (Predicted-Measured)^2
		7.70%	4.98506E-05
		7.59%	0.000308701
		4.29%	3.71095E-05
		4.33%	3.65862E-06
		6.14%	5.75335E-05
		6.12%	0.00011936
		-	0
		-	0
		-	0
		-	0
		-	0
		-	0

(a)

Expansive Deposits Inputs

Layer 1

Soil	HB	-
LL	81	%
PI	55	%
% -No.40	100	%
ω=	24%	%
γ_d=	90	pcf
γ=	112	pcf
Thickness	4.0	ft

Note: Correlations for ω_{opt} and γ_d are from USACOE 1995

A	-0.077
B	0.2375

"Swell Pressure": 1174 psf

Lime-Treated Expansive Deposit Inputs

Layer 1

Amount HL	4	%
Treatment Depth	0	ft

A	-0.005	RMSE:	1.67E-03
B	0.0163	r^2:	0.6193

Equiv. Stress (psf)	Swell (%)	Swell, Predicted (%)	Error (Predicted-Measured)^2
1174	0.00%	0.00%	5.55935E-11
		0.45%	4.17174E-06
		0.45%	4.20317E-06

(b)

Figure 6-18. PVR Calculation Inputs for (a) Untreated, (b) Lime-Treated Soil Swell Data

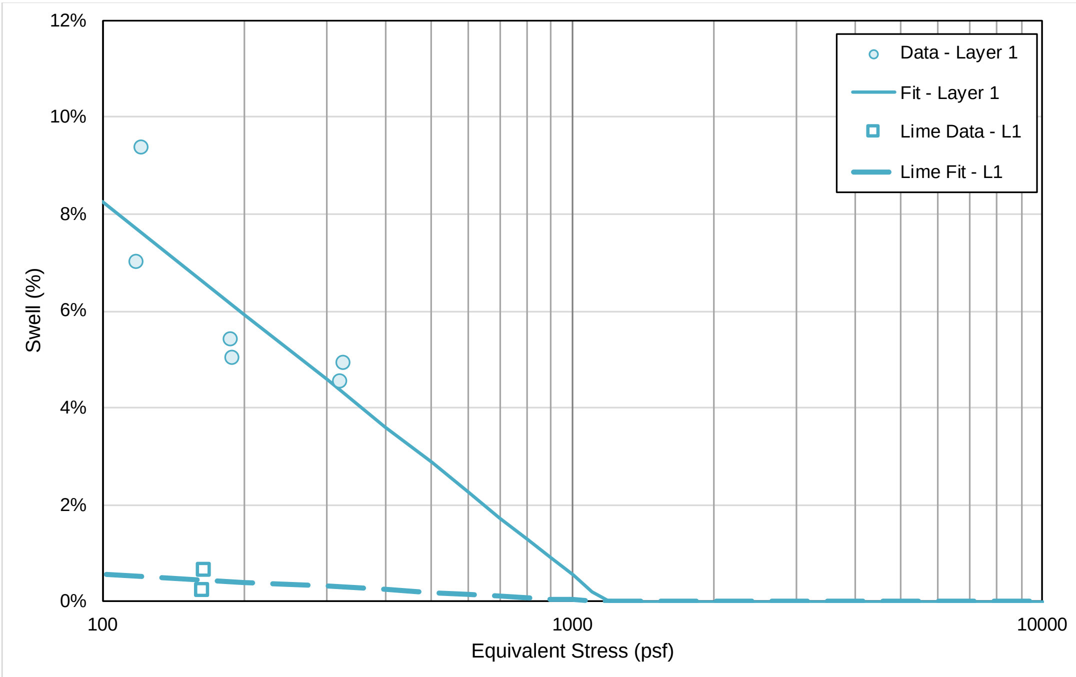


Figure 6-19. Example of Untreated and Lime-Treated Stress-Swell Lines for PVR Calculation

The above process is repeated for each layer in the soil stratum, and the stress-swell best-fit lines are then used to calculate the PVR by numerically integrating over the range of stresses in the soil using the trapezoidal rule over 0.5 ft intervals. The calculation table is shown in Figure 6-20, and the total PVR for the given soil stratum is highlighted as shown.

Layer Count	Depth to Bottom of Layer [ft]	Layer	Soil	Top Load [psf]	Bottom Load [psf]	Average Load [psf]	Average Load [psi]	Percent Moisture	Unit Weight [pcf]	Percent -No.40	Slope "A"	Y-Intercept "B"	Average Swell (%)	Incremental PVR (in)	Data PVR (in)
1	0	-		0	173	87	0.6	-		-	-	-	-	-	**2.62**
2	0.5	1	HB	173	229	199	1.4	23.8	112	100	-0.077	0.238	6.0%	0.358	2.26
3	1	1	HB	229	285	256	1.8	23.8	112	100	-0.077	0.238	5.1%	0.307	1.95
3	1.5	1	HB	285	341	312	2.2	23.8	112	100	-0.077	0.238	4.5%	0.267	1.68
4	2	1	HB	341	397	368	2.6	23.8	112	100	-0.077	0.238	3.9%	0.234	1.45
5	2.5	1	HB	397	452	424	2.9	23.8	112	100	-0.077	0.238	3.4%	0.206	1.24
6	3	1	HB	452	508	479	3.3	23.8	112	100	-0.077	0.238	3.0%	0.181	1.06
7	3.5	1	HB	508	564	535	3.7	23.8	112	100	-0.077	0.238	2.6%	0.158	0.90
8	4	1	HB	564	620	591	4.1	23.8	112	100	-0.077	0.238	2.3%	0.138	0.77
9	4.5	2	HB	620	674	647	4.5	25.7	109	100	-0.073	0.223	1.9%	0.112	0.65
10	5	2	HB	674	729	701	4.9	25.7	109	100	-0.073	0.223	1.6%	0.097	0.56
11	5.5	2	HB	729	784	756	5.2	25.7	109	100	-0.073	0.223	1.4%	0.083	0.47
12	6	2	HB	784	838	810	5.6	25.7	109	100	-0.073	0.223	1.2%	0.070	0.40
13	6.5	3	HB	838	893	865	6.0	25.7	109	100	-0.071	0.222	1.4%	0.086	0.32
14	7	3	HB	893	947	920	6.4	25.7	109	100	-0.071	0.222	1.2%	0.075	0.24
15	7.5	3	HB	947	1002	974	6.8	25.7	109	100	-0.071	0.222	1.1%	0.064	0.18
16	8	3	HB	1002	1057	1029	7.1	25.7	109	100	-0.071	0.222	0.9%	0.054	0.13
17	8.5	3	HB	1057	1111	1084	7.5	25.7	109	100	-0.071	0.222	0.7%	0.045	0.08
18	9	3	HB	1111	1166	1138	7.9	25.7	109	100	-0.071	0.222	0.6%	0.035	0.05
19	9.5	3	HB	1166	1220	1193	8.3	25.7	109	100	-0.071	0.222	0.4%	0.027	0.02
20	10	3	HB	1220	1275	1247	8.7	25.7	109	100	-0.071	0.222	0.3%	0.019	0.00

Figure 6-20. PVR Calculation Table

7. UNTREATED PVR AND LIME-TREATED PVR CALCULATIONS

A set of examples was compiled to illustrate the analysis method presented above. The two soil borings were taken from a section of US-87 from IH-10 to Rigsby Rd. in Bexar County, San Antonio. The section of US-87 under consideration consists of about 0.6 miles of a 4-lane uncontrolled access highway between IH-10 and Rigsby Rd. Figure 7-1 shows a Google Earth® map of the site. According to a digitized version of the NGS topographic map, the northwest end of the road is situated about 700 ft above MSL, while the southeast end is situated about 620 ft above MSL.

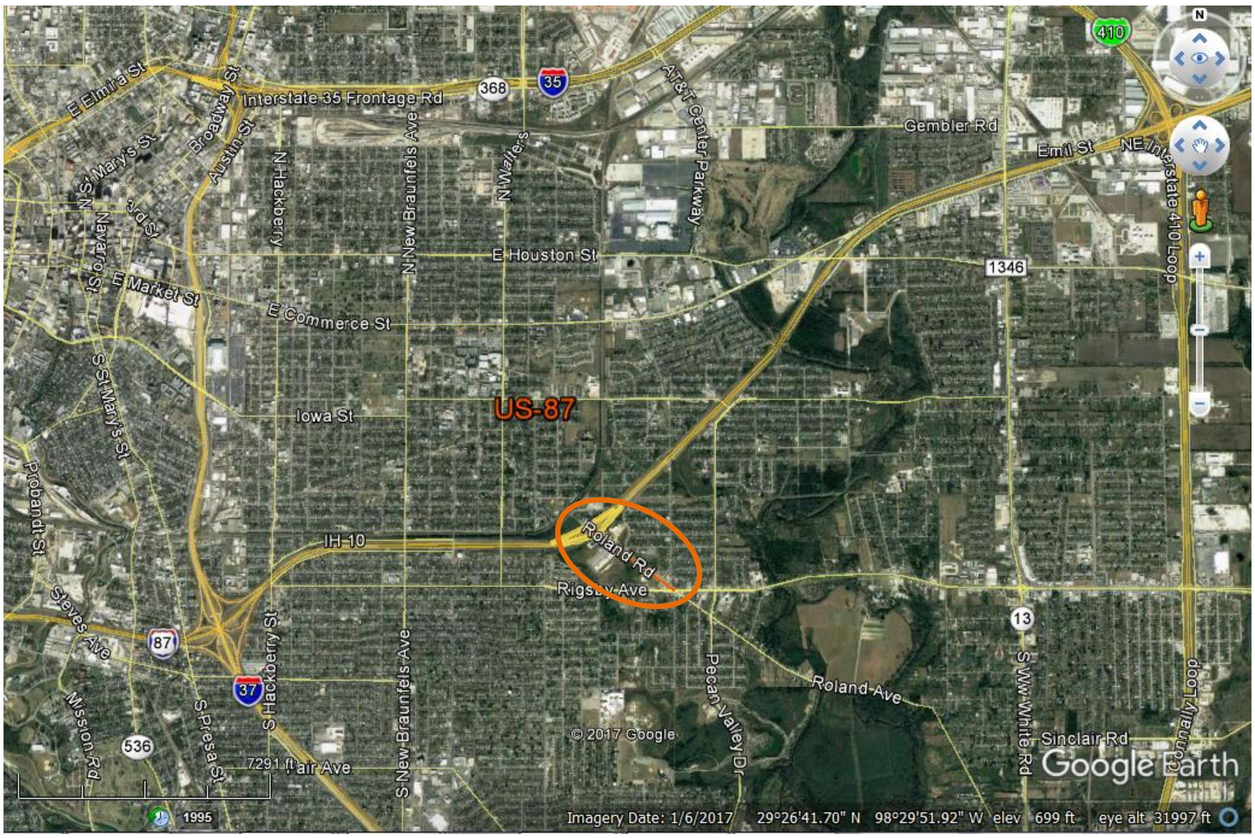


Figure 7-1. Google Earth® imagery of US-87 at Rigsby Road and surrounding area

The site was identified for a re-design due to excessive heaving, as observed in Figure 7-2:

Figure 7-2. Heaving in NW-bound lane of site (left) facing southeast, (right) facing northwest

Figure 7-3 shows a colorized USDA soil survey map overlay on the Google Earth satellite image. The major soil horizons identified in the highway alignment are the Houston Black, Olmos, and Branyon soils.

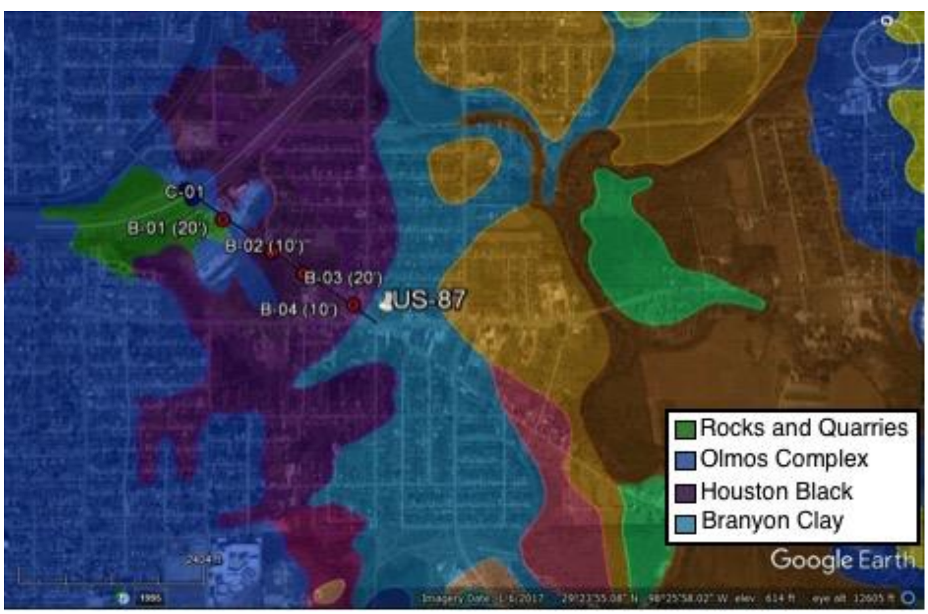


Figure 7-3. USDA Soil Survey map over satellite image of site and surrounding area

Borings were conducted using a 4” solid stem auger (Figure 7-4a) and cuttings were collected over 2-ft intervals from the top 8 ft in Borings 1, 2, and 4. The presence of the existing asphalt surface (shown in Figure 7-4b) minimized cross contamination between cuttings from different depths.

(a) (b)

Figure 7-4. (a) Solid stem auger used to perform borings; (b) Samples being collected

The PVR testing considers only soils that are within 10 feet of the surface or soils that were encountered deeper in uphill boreholes that may be expected to outcrop on the surface somewhere along the alignment based on the perceived layering in the geologic maps.

Table 7-1 shows the results of Atterberg limits and calculated Target Compaction Conditions for the centrifuge PVR determinations for each of these soils. The target compaction conditions were calculated using equations from USACOE (1995) as specified in Chapter 6. A specific gravity of 2.7 was assumed for all soils.

Table 7-1. Atterberg Limits and Target Compaction Conditions for Centrifuge PVR

Boring	Depth	LL	PL	PI	Target Water Content (USACOE, 1995)	Target Max Dry Density (pcf) (USACOE, 1995)
B-02	0.5' – 4'	81	26	55	23.8%	90
B-02	4' – 6'	89	22	67	25.7%	87
B-02	6' – 10'	89	25	64	25.7%	87
B-04	0.5' – 2'	72	21	51	21.6%	94
B-04	2' – 4'	74	24	50	22.1%	93
B-04	4' – 6'	74	22	52	22.1%	93

In accordance with the reduced procedure, the stress swell curves were first measured on the native soil, and then the lime treated soils were tested at a representative stress condition, and a stress-swell line was created by connecting this data with the extrapolated swell pressure of the native soil, as detailed in Sections 7.1 and 7.2.

7.1. US-87 Boring B-02

7.1.1. ADOPTED SOIL PROFILE FOR US 87 B-02

The soil samples from this site were taken were taken within the Houston Black soil complex. The pavement structure considered for PVR calculations had an asphalt depth of 4 inches and a base layer of 10 inches. The adopted profile is consistent among the sampling locations in order to provide a similar comparison between sites in terms of the range of stresses. Soil samples were obtained and characterized from depths of 0' – 4', 4' – 6', and 6' – 10', and each were treated as separate layers. Layer 1 was assumed to be at a dry of optimum moisture content of 23.8% and a relative compaction of 100%, resulting in a dry unit weight of 90 pcf and a total unit weight of 112 pcf. Layer 2 was assumed to be at a dry of optimum moisture content of 25.7% and a relative compaction of 100%, resulting in a dry unit weight of 87 pcf and a total unit weight of 109 pcf. Layer 3 was assumed to be at a dry of optimum moisture content of 25.7% and a relative compaction of 100%, resulting in a dry unit weight of 95 pcf and a total unit weight of 109 pcf. The soil profile used for both methods is shown in Table 7-2.

Table 7-2. Assumed Soil Profile for Houston Black at US 87 B-02

Layer	Depths [ft]		Soil	LL	PL	PI	Water Content [%]	Unit Weight [pcf]	Average Pressure	
	From	To							[psf]	[psi]
-	+1.2	0	*Asphalt + Base Material	0	0	0	-	Varies	173	1.2
1	0	2	Houston Black	81	26	55	23.8%	112	397	2.8
1	2	4							620	4.3
2	4	6	Houston Black	89	22	68	25.7%	109	838	5.8
3	6	8	Houston Black	89	25	64	25.7%	109	1057	7.3
3	8	10							1275	8.9
***Asphalt + Base Material Pressure is Assumed as a Total Applied Surcharge Load on Top of Soil Layer**										

7.1.2. PVR CALCULATIONS FOR US 87 B-02

The soil conditions for centrifuge testing program on the Houston Black soil from US 87 B-02 included an initial moisture content of 23.5%, 22.5%, and 26.3% for Layers 1, 2, and 3, respectively, and a relative compaction of 100% for all layers. Tests were completed at the prescribed stresses in the same centrifuge test to generate the necessary data. Data from centrifuge tests were input into the DMS-C spreadsheet. From the data in Table 7-2, it is apparent that this soil will be fairly expansive and will likely require remediation efforts.

The PVR for Boring B-02 is calculated using both the “Conventional” and the “Optimized Method”. The Conventional Method uses the 3-parameter curve fitting function for each layer’s stress-swell curve, which is fit to points at 3 effective stresses for each layer. The Optimized Method uses a straight line in semi log space for each layer’s stress-swell curve, also using points at 3 effective stresses for each layer

. By numerically integrating the curve fitted functions for each layer from Figure 7-5 using the trapezoid rule with 1,000 divisions between the top and bottom stresses of 173 and 1275 psf, the PVR of the subgrade was determined to be 2.29 in for the Conventional Method. By numerically integrating the best-fit line for each layer from Figure 7-6 using the trapezoid rule with 20 divisions between the top and bottom stresses of 173 and 1275 psf, the PVR of the subgrade was determined to be 2.62 in for the Optimized Method.

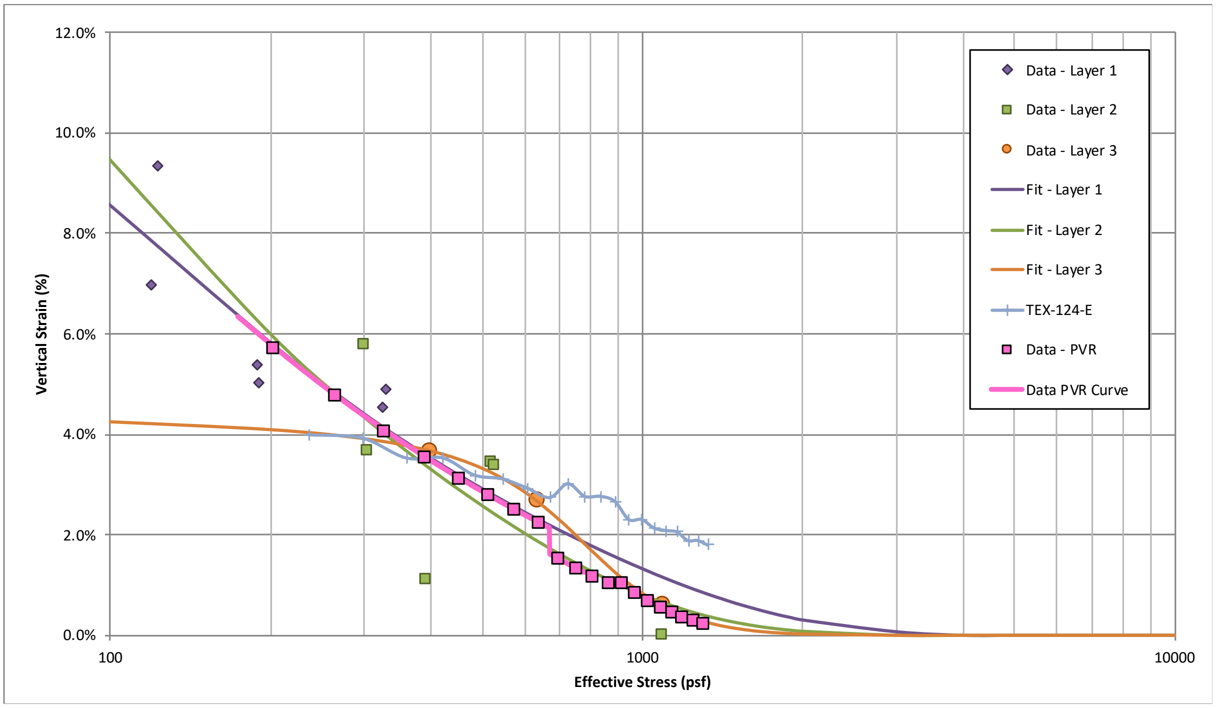


Figure 7-5. Swelling Curves from Centrifuge Data for B-02 Conventional Method

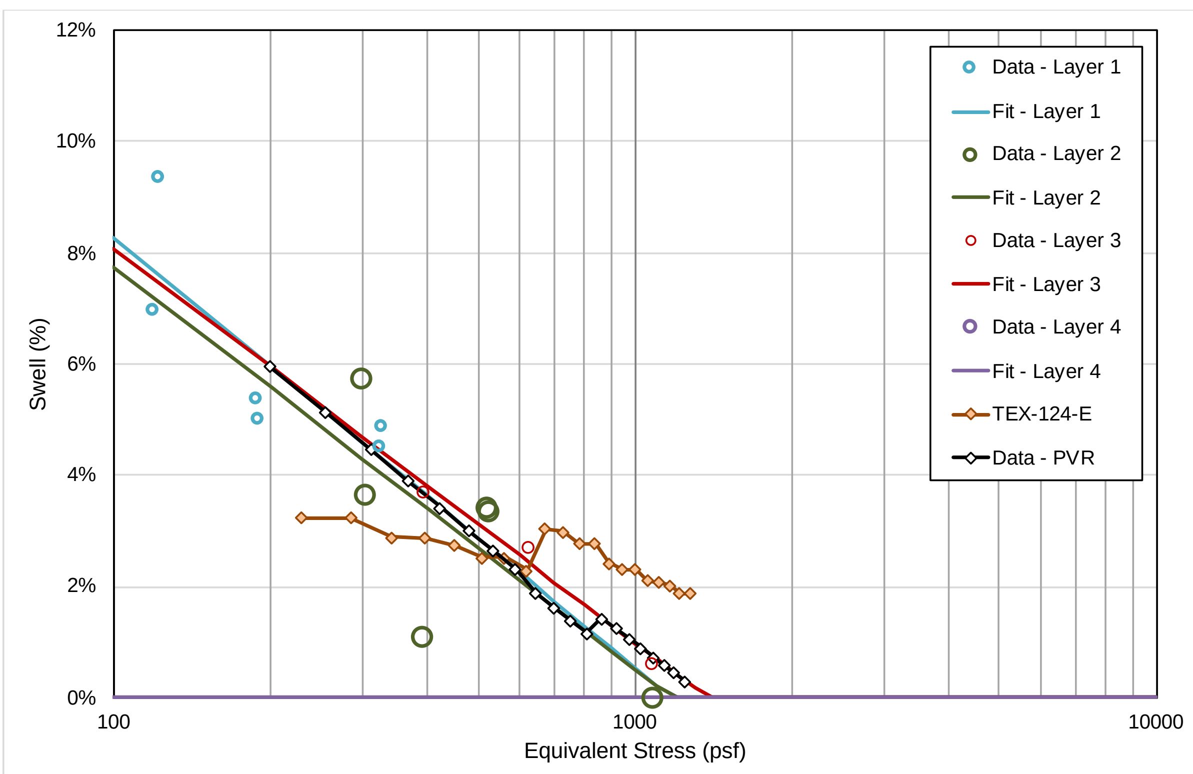


Figure 7-6. Stress-Swell Lines from Centrifuge Data for B-02 Optimized Method

Table 7-3 and Figure 7-7 compare the calculated PVR for each method. In this case, the Optimized Method calculates a PVR that is 14.4% higher than the PVR calculated with the Conventional Method using 3-parameter curves.

Table 7-3. Comparison of B-02 PVR for Initial and Optimized Methods

PVR Calculated from Conventional Method [in]	**PVR Calculated from Optimized Method [in]**	**Difference [%]**
2.29	2.62	14.4%

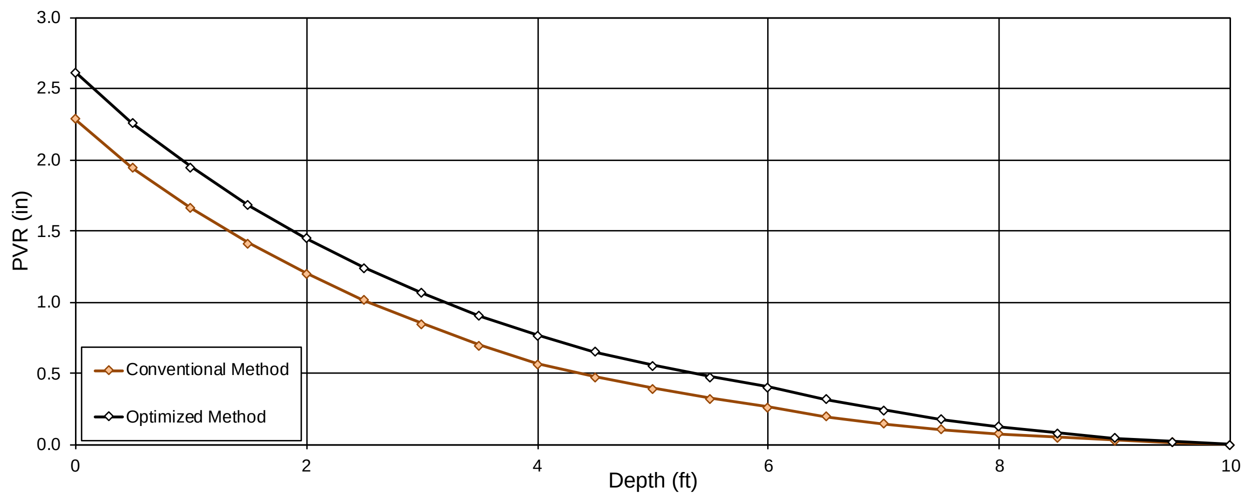


Figure 7-7. Comparison of B-02 PVR with Depth for Initial and Optimized Methods

7.1.3. LIME TREATED PVR FOR US 87 B-02

Next, the process was repeated for each method using soil from each layer treated with 4% by dry mass of hydrated lime. For testing purposes, multiple concentrations of lime should be used; however, for illustrative purposes, only 4% lime is shown. For the Conventional Method, a full stress-swell curve was tested for B-02 at a depth of 0' – 4', and a 3-parameter curve was fit to this data (shown in Figure 7-8 as the 'Layer 1' purple data points and line). The existing soil previously denoted as Layer 1, Layer 2, and Layer 3 are now denoted as Layer 2, Layer 3, and Layer 4, respectively. The PVR was again calculated by numerically integrating the curve fitted functions for each layer from Figure 7-8 using the trapezoid rule with 1,000 divisions between the top and bottom stresses of 173 and 1275 psf. By varying the depth of treatment (thickness of Layer 1, and subsequently decreasing the thickness of the untreated soil in Layer 2), a variation in PVR with treatment depth was determined.

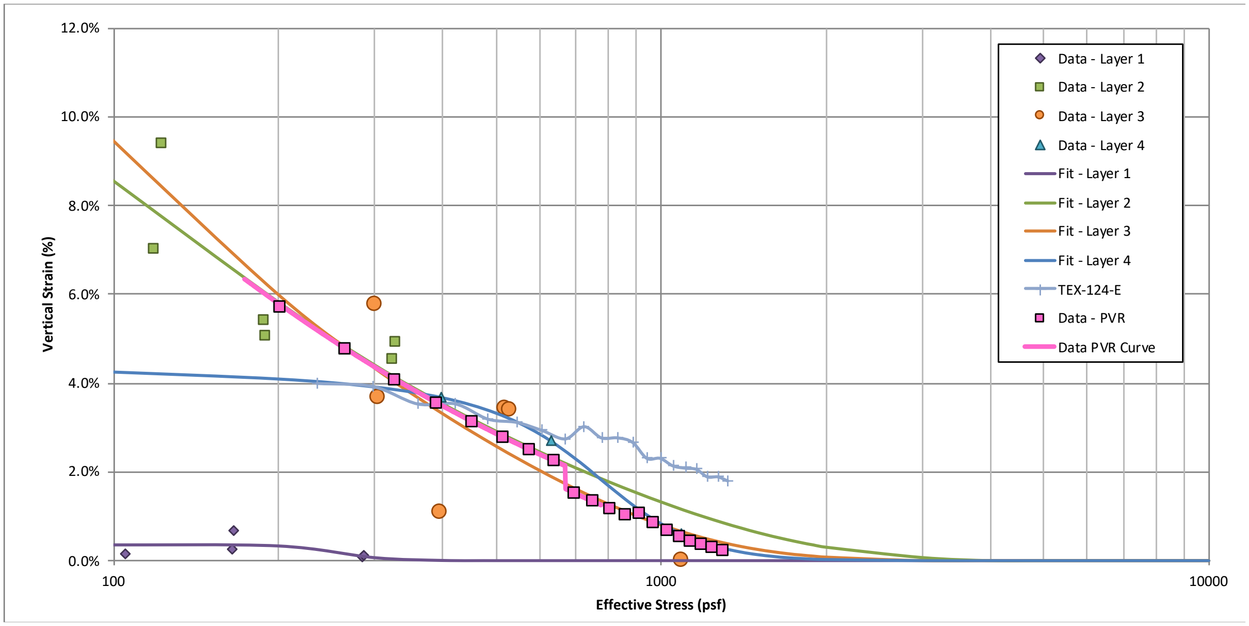


Figure 7-8. Lime-Treated Swelling Curves from Centrifuge Data for B-02 Conventional Method

For the Optimized Method, 2 data points were obtained at a stress of approximately 165 psf for B-02 at a depth of 0' – 4'. These points were connected to the calculated swell pressure of the untreated stress-swell line for B-02 at a depth of 0' – 4' (shown in Figure 7-9 as the 'Lime Layer 1' in turquoise). The PVR was determined by numerically integrating the best-fit line for each layer from Figure 7-9 using the trapezoid rule with 20 divisions between the top and bottom stresses of 173 and 1275 psf. By varying the treatment depth of the Lime-Treated Layer 1, a variation in PVR with treatment depth was determined.

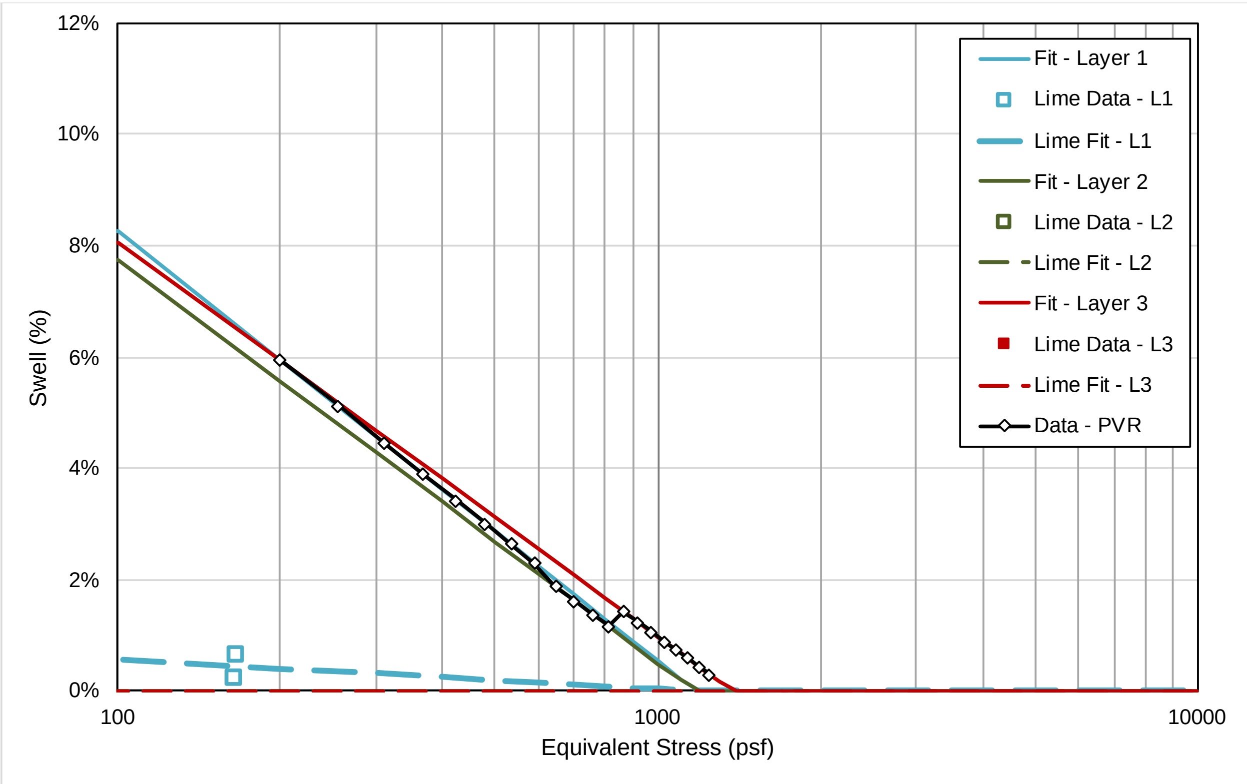


Figure 7-9. Lime-Treated Stress-Swell Lines from Centrifuge Data for B-02 Optimized Method

The variation in PVR with depth is shown in Figure 7-10 for the Conventional Method and the Optimized Method. Horizontal lines are shown in the graph at values of 1.5 inches and 1.0 inches, which are typical prescribed maximum PVR values for transportation projects. Table 7-4 compares the depth of treatment to reach each PVR for the Initial and Optimized Methods. As can be seen, the Optimized Method suggests treating 6 – 9 inches deeper than the Conventional Method does, which stems from the initial difference in untreated PVR.

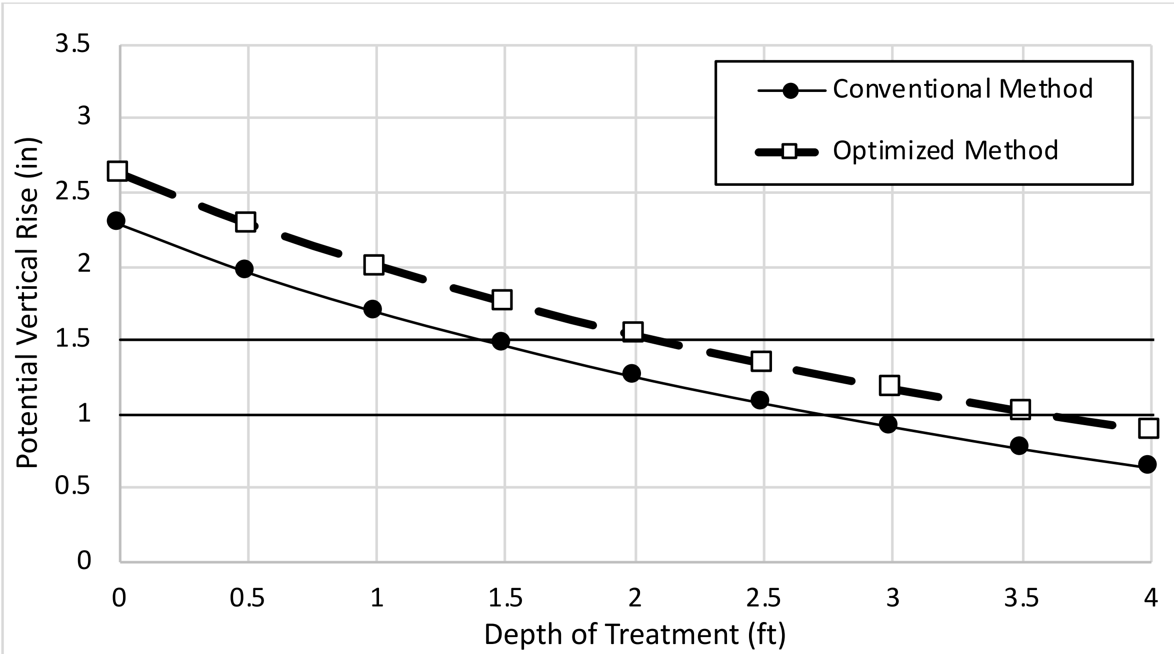


Figure 7-10. Comparison of PVR Reduction with Depth of 4% Lime Treatment for Initial and Optimized Methods

Table 7-4. Comparison of Treatment Depth to Reach PVR Requirements for B-02 using Initial and Optimized Methods

Prescribed PVR [in]	**Depth of Required Lime Treatment [ft]**	
	Conventional Method	**Optimized Method**
1.5	1.5	2
1	2.75	3.5

7.2. US-87 Boring B-04

7.2.1. ADOPTED SOIL PROFILE FOR US 87 B-04

The soil samples from this site were taken were taken within the Houston Black soil complex. The pavement structure considered for PVR calculations had an asphalt depth of 4 inches and a base layer of 10 inches. The adopted profile is consistent among the sampling locations in order to provide a similar comparison between sites in terms of the range of stresses. Soil samples were obtained and characterized from depths of 0’ – 2’, 2’ – 4’, and 4’ – 6’, and each were treated as separate layers. To be more directly comparable to other borings from the site, Layer 3 was extended to a depth of 10 feet. Layer 1 was assumed to be at a dry of optimum moisture content of 21.6% and a relative compaction of 100%, resulting in a dry unit weight of 94 pcf and a total unit weight of 114 pcf. Layer 2 was assumed to be at a dry of optimum moisture content of 22.1% and a relative compaction of 100%, resulting in a dry unit weight of 93 pcf and a total unit weight of 114 pcf. Layer 3 was assumed to be at a dry of optimum moisture content of 22.1% and a relative compaction of 100%, resulting in a dry unit weight of 93 pcf and a total unit weight of 114 pcf. The soil profile used for both methods is shown in Table 7-5.

Table 7-5. Assumed Soil Profile for Houston Black at US 87 B-04

Layer	Depths [ft]		Soil	Liquid Limit	Plastic Limit	Plasticity Index	Water Content [%]	Unit Weight [pcf]	Average Pressure	
	From	To							[psf]	[psi]
-	+1.2	0	*Asphalt + Base Material	0	0	0	-	Varies	173	1.2
1	0	2	Houston Black	72	21	50	21.6%	114	402	2.8
2	2	4	Houston Black	74	24	50	22.1%	114	629	4.4
3	4	6	Houston Black	74	22	52	22.1%	114	856	5.9
3	6	8							1084	7.5
3	8	10							1311	9.1
***Asphalt + Base Material Pressure is Assumed as a Total Applied Surcharge Load on Top of Soil Layer**										

7.2.2. PVR CALCULATIONS FOR US 87 B-04

The soil conditions for centrifuge testing program on the Houston Black soil from US 87 B-04 included an initial moisture content of 21.8%, 21.3%, and 20.7% for Layers 1, 2, and 3, respectively, and a relative compaction of 100% for all layers. Tests were completed at the prescribed stresses in the same centrifuge test to generate the necessary data. Data from centrifuge tests were input into the DMS-C spreadsheet. From the data in Table 7-5, it is apparent that this soil will be fairly expansive and will likely require remediation efforts.

The PVR for Boring B-04 is calculated using both the "Conventional Method" and the "Optimized Method", where the Conventional Method uses the 3-parameter curve fitting function for each layer's stress-swell curve, and the Optimized Method uses a straight line in semi log space for each layer's stress-swell curve. By numerically integrating the curve fitted functions for each layer from Figure 7-11 using the trapezoid rule with 1,000 divisions between the top and bottom stresses of 173 and 1311 psf, the PVR of the subgrade was determined to be 5.34 in for the Conventional Method. By numerically integrating the best-fit line for each layer from Figure 7-12 using the trapezoid rule with 20 divisions between the top and bottom stresses of 173 and 1311 psf, the PVR of the subgrade was determined to be 5.62 in for the Optimized Method.

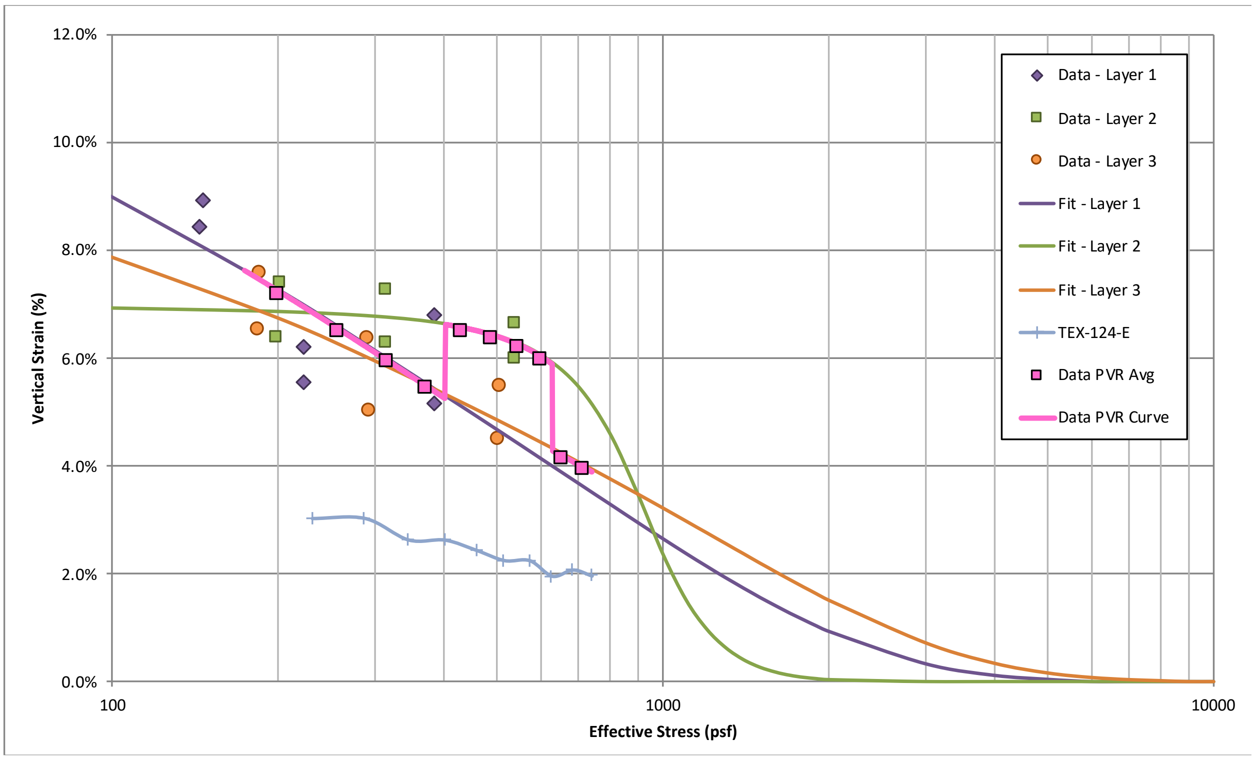


Figure 7-11. Swelling Curves from Centrifuge Data for B-04

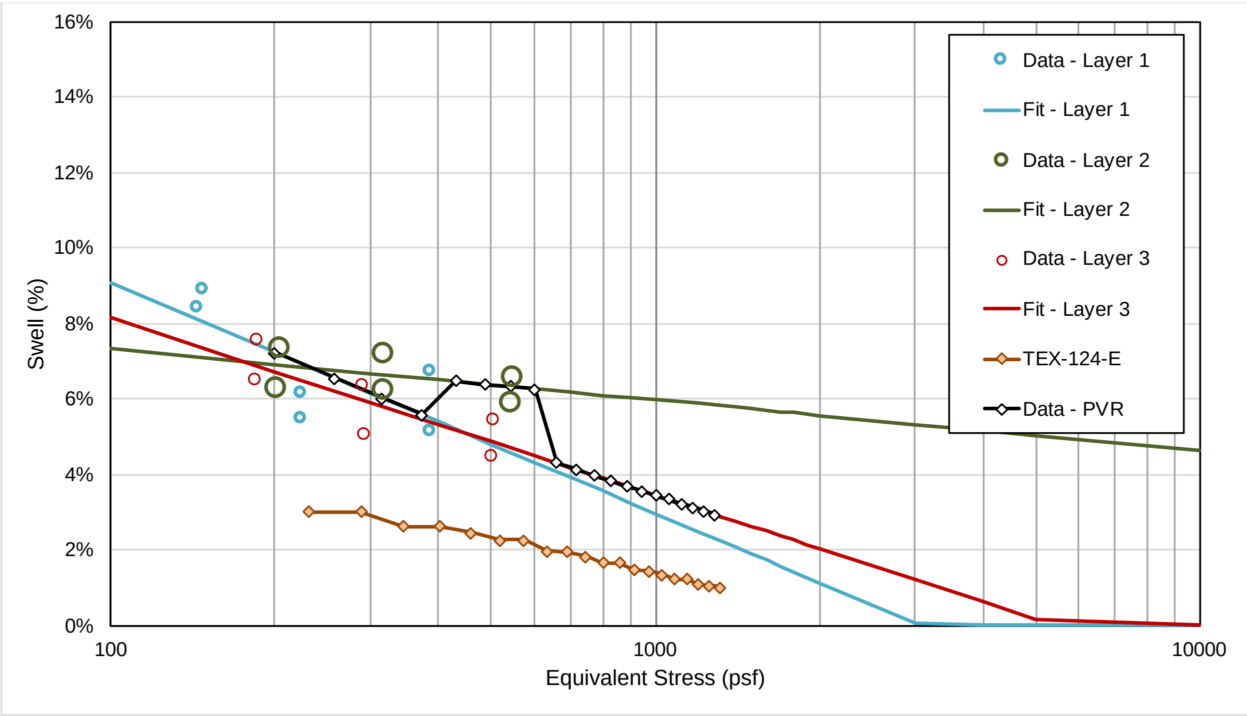


Figure 7-12. Reduced Stress-Swell Lines from Centrifuge Data for B-04

Table 7-6 and Figure 7-13 compare the calculated PVR for each method. In this case, the Optimized Method calculates a PVR that is 5.2% higher than the PVR calculated with the Conventional Method using 3-parameter curves.

Table 7-6. Comparison of B-04 PVR for Initial and Optimized Methods

PVR Calculated from Conventional Method [in]	**PVR Calculated from Optimized Method [in]**	**Difference [%]**
5.34	5.62	5.2%

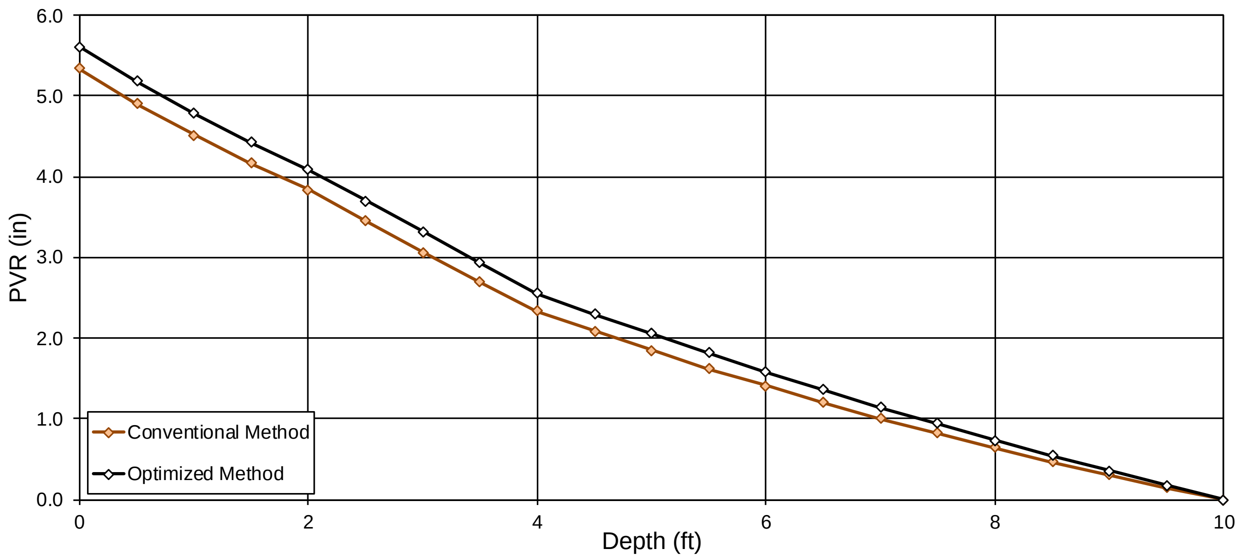


Figure 7-13. Comparison of B-04 PVR with Depth for Initial and Optimized Methods

7.2.3. Lime Treated PVR for US 87 B-04

Next, the process was repeated for each method using soil from each layer treated with 4% by dry mass of hydrated lime. For testing purposes, multiple concentrations of lime should be used; however, for illustrative purposes, only 4% lime is shown. For the Conventional Method, a full stress-swell curve was tested for B-04 at a depth of 0' – 2', and a 3-parameter curve was fit to this data. For treated soils at a depth of 2' – 4' and 4' – 10', swell data was obtained at a representative stress for each layer, and the 3-parameter curve was fit to this data. The existing soil previously denoted as Layer 1, Layer 2, and Layer 3 are now denoted as Layer 2, Layer 3, and Layer 4, respectively. The PVR was again calculated by numerically integrating the curve fitted functions for each layer from Figure 7-14 using the trapezoid rule with 1,000 divisions between the top and bottom stresses of 173 and 1311 psf. By varying the depth of treatment (thickness of Layer 1, and subsequently decreasing the thickness of the untreated soil in Layer 2), a variation in PVR with treatment depth was determined.

Because this soil required a significantly higher treatment depth than the previous example, the process of increasing treatment depth to calculate PVR was repeated into deeper layers. After the entirety of the 0' – 2' layer was "treated", Layer 1 remained a constant 2-ft thick layer of treated soil, and Layer 2 represented the treated section of the 2' – 4' soil layer while Layer 3 represented the remaining untreated section of the 2' – 4' soil. After the entirety of the 2' – 4' layer was "treated", Layer 2 remained a constant 2-ft thick layer of treated soil, and Layer 3 represented the treated section of the 4' – 10' soil layer while Layer 4 represented the remaining untreated section of the 4' – 10' soil. 7-7 documents the changes in labeled soil layers with treatment depth for B-04 as tested with the Conventional Method. The darker shaded boxes represent layers with variable thicknesses, and the lighter yellow shaded boxes represent layers with constant thicknesses.

Table 7-7. Soil Layers Used for Calculating Lime-Treated PVR for B-04 in Conventional Method

Layer	**Depth of Treatment**		
	0 ft – 2 ft	**2 ft – 4 ft**	**4 ft – 10 ft**
1	0' – 2' Lime Treated	0' – 2' Lime Treated	0' – 2' Lime Treated
2	0' – 2' Untreated	2' – 4' Lime Treated	2' – 4' Lime Treated
3	2' – 4' Untreated	2' – 4' Untreated	4' – 10' Lime Treated
4	4' – 10' Untreated	4' – 10' Untreated	4' – 10' Untreated

For the Optimized Method, 2 data points were obtained for B-04 at a stress of approximately 175 psf for a depth of 0' – 2', a stress of approximately 400 psf for a depth of 2' – 4', and a stress of approximately 500 psf for a depth of 4' – 10'. These points were connected to the calculated swell pressure of the untreated stress-swell line for B-02 at their respective depths. The PVR was determined by numerically integrating the best-fit line for each layer from Figure 7-15 using the trapezoid rule with 20 divisions between the top and bottom stresses of 173 and 1311 psf. By varying the treatment depth of the Lime-Treated Layers 1-3, a variation in PVR with treatment depth was determined.

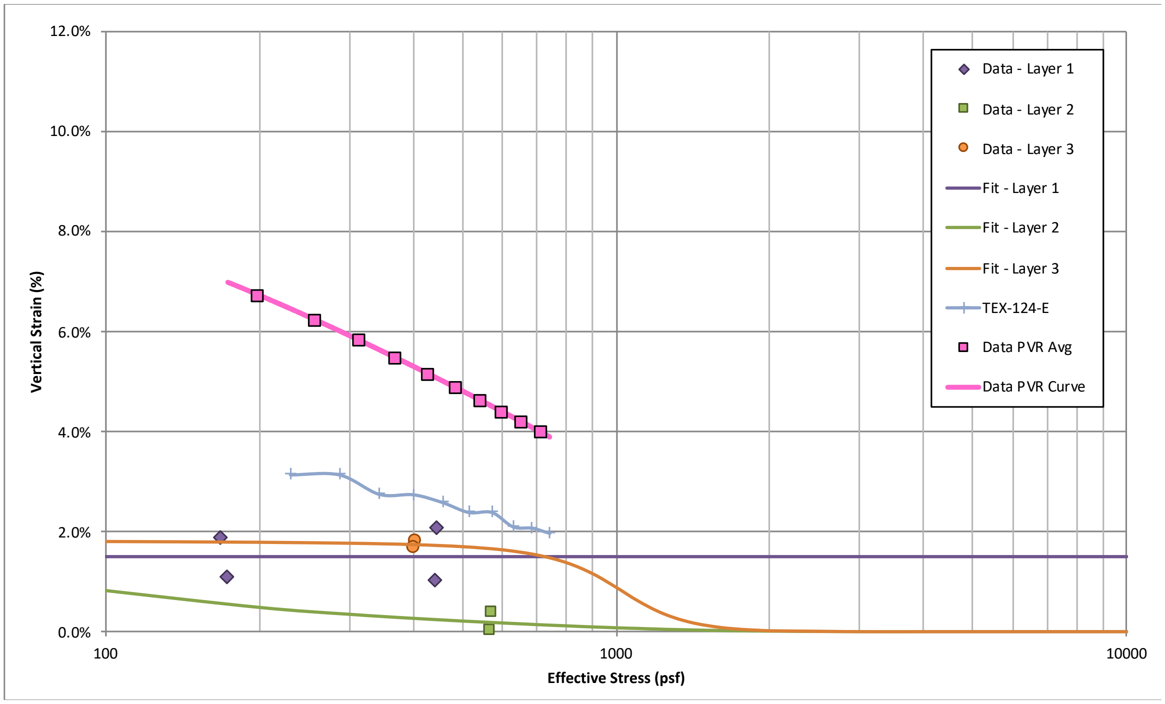


Figure 7-14. Lime-Treated Swelling Curves from Centrifuge Data for B-04

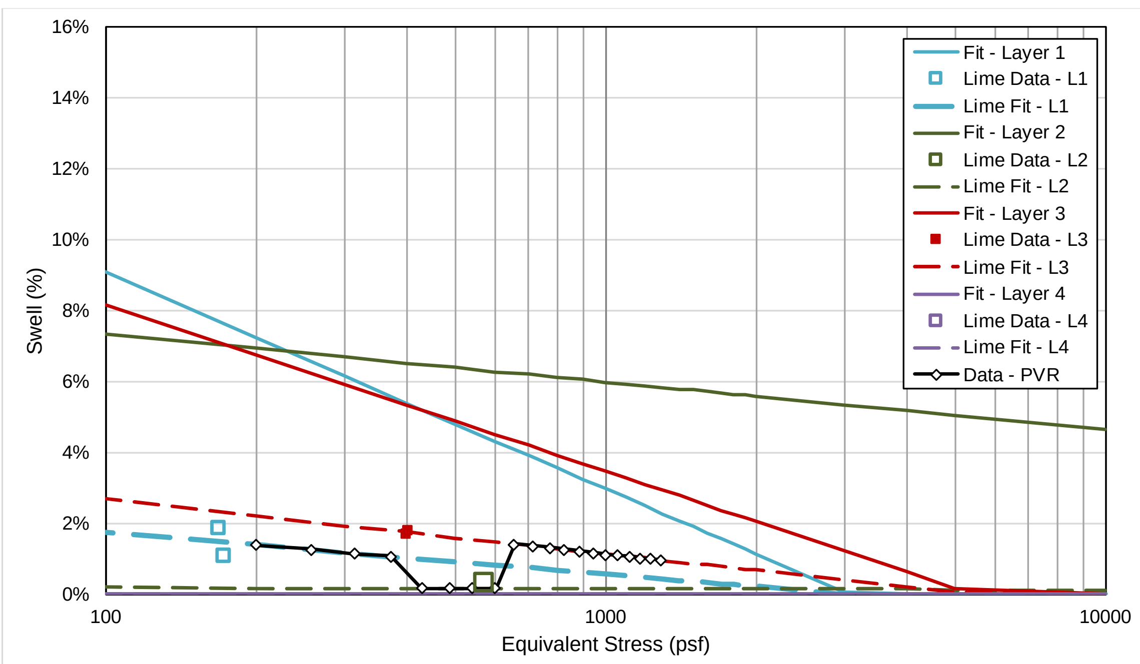


Figure 7-15. Lime-Treated Swelling Optimized Stress-Swell Lines from Centrifuge Data for B-04

The variation in PVR with depth is shown in Figure 7-16 for the Conventional Method and the Optimized Method. Horizontal lines are shown in the graph at values of 2.5 inches, 1.5 inches, and 1.0 inches, which are typical prescribed maximum PVR values for transportation projects. Table 7-8 compares the depth of treatment to reach each PVR for the Initial and Optimized Methods. As can be seen, the Optimized Method matches very well with the Conventional Method in this case.

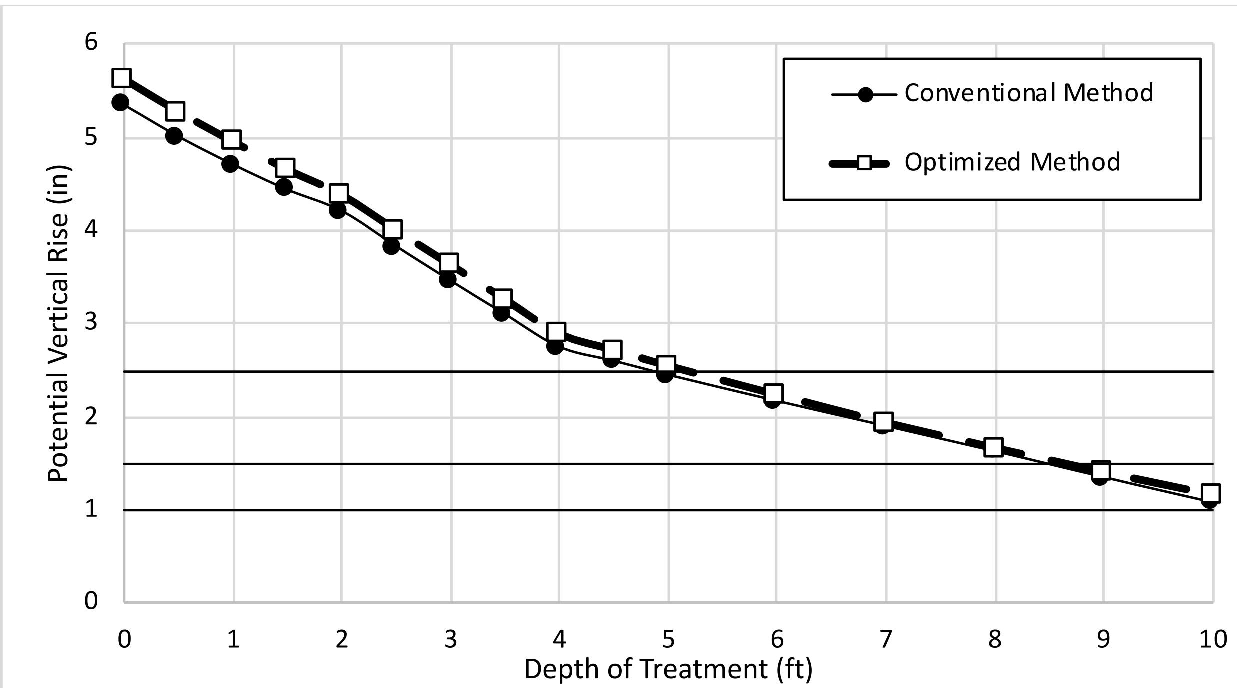


Figure 7-16. Comparison of PVR Reduction with Depth of 4% Lime Treatment for B-04 using Conventional and Optimized Methods

Table 7-8. Comparison of Treatment Depth to Reach PVR Requirements for B-04 using Conventional and Optimized Methods

Prescribed PVR [in]	**Depth of Required Lime Treatment [ft]**	
	Conventional Method	**Optimized Method**
2.5	5	5.25
1.5	8.5	8.5
1	10	10

8. CONCLUSIONS

Based on the data and analyses presented above regarding centrifuge testing on Eagle Ford clay, the following conclusions may be drawn:

- As corroborated by previous research, the magnitude of non-cyclical swell in untreated soil depends significantly on initial compaction conditions – moisture content and dry density/void ratio. In Eagle Ford clay, an increase of moisture content by 1% decreases the swell potential by approximately 1%. Variation in dry density has a less significant effect on swelling; for a 4 psf increase in dry density, the swell potential increases by 1%.
- When tested under the same initial compaction conditions and at the same effective stress, measured swell is linearly related to the added mass of hydrated lime, until the swell potential of the soil is reduced to zero.
- The effects of mellowing and curing of treated samples for centrifuge testing do not significantly affect calculated swelling potential. For the purposes of testing in the centrifuge, samples do not need to be cured and can be mellowed for 1-2 days to accommodate mixing and testing.
- Stress-swell curves for both untreated and lime-treated soils can be reasonably approximated by a line in semi-log space from stress ranges of approximately 100 psf to 1000 psf or to the point of zero swell. The addition of lime to soil decreases both the slope and intercept of this stress-swell line.

Based on the data and analyses presented above regarding the potential sources of error present in the centrifuge testing process, the following conclusions may be drawn:

- The amount of vacuum grease used in sample preparation does not seem to significantly affect swell. However, the use of vacuum grease may decrease scatter in test results and is still recommended to use in test setup.
- Air dried and oven dried samples will also have different swell potential. This is because the high temperature of oven drying affects the soil structure and can remove water from between clay sheets, which does not occur during air drying at room temperature.
- The amount of error that can be seen in centrifuge testing among otherwise identically compacted samples is generally +/- 1.5% total swell. The scatter in swell potential of

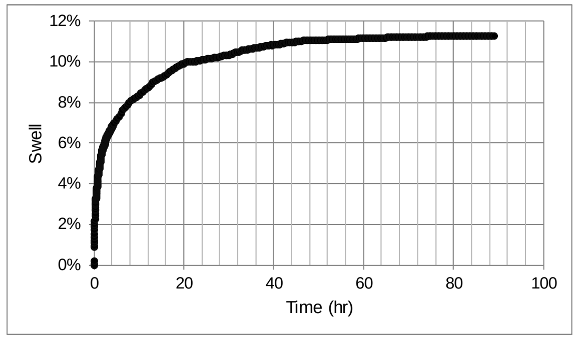
samples that have identical compaction conditions is most likely from small variations in voids due to compaction, affecting infiltration of water through sample, or from heterogeneity in soil.

Based on the data and analyses presented above regarding the new methodology for optimization of lime treatment of expansive clays, the following conclusions may be drawn:

- For laboratory testing purposes, soil should be mixed air-dry with hydrated lime and then moisture conditioned. This serves to reduce variability in test results and is easier to mix.
- For untreated Eagle Ford clay, the swell pressure was estimated through extrapolation of the centrifuge stress-swell curves and was found to be 3500 psf. For Eagle Ford treated with 4% hydrated lime, the swell pressure calculated by extrapolation of the centrifuge stress-swell curves were found to be 3000 psf from extrapolation of the 3-parameter stress-swell curve and 5500 psf from extrapolation of the stress-swell line. This helps to illustrate the inherent variability in determining the swell pressure of a soil sample from extrapolation of a curve.
- Free swell tests were performed on Eagle Ford treated with 4% hydrated lime, and the swell pressure in this method was found to be 2100 psf. This calculated value is significantly lower than that calculated through extrapolation of the stress-swell line, again illustrating the variability in swell pressure determination with different testing methods.
- For the purposes of calculating PVR for lime-treated soil strata, the approximation of a constant swell pressure is considered to be adequate. As shown by PVR calculations of lime-treated soils at US 87, the calculated values vary by 5% - 14%, which corresponds to a variation in treatment depth of 6 – 9 inches. The assumption of a unique swell pressure for both untreated and treated samples of a given soil allows for testing protocols that can expedite number of tests required for practical purposes.

APPENDIX A: UNTREATED EAGLE FORD CLAY CENTRIFUGE TEST RESULTS

Date test conducted	2/23/2018	
Centrifuge used	3	
Cup Number	3	
Conducted by	Karly	



SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

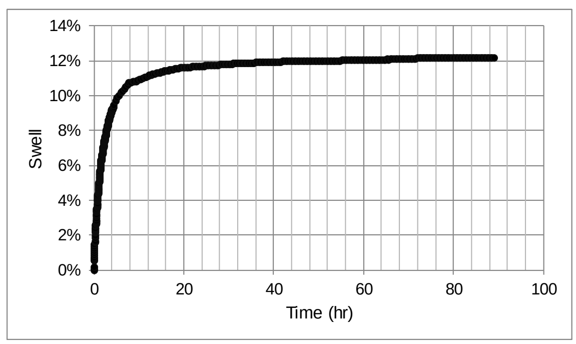
TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.97	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	38.04	38.00	g
	Dry Unit Weight	14.65	14.66	kN/m3
	Height of Sample	1.000	1.013	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.061	cm
	Testing Height	1.006	1.119	cm
	Void Ratio, e	0.834	1.041	-
	Moisture Content	24.8%	43.0%	%
	Saturation	81.4%	100.0%	%
	Change in Moisture Content	-	18.3%	%
	Overburden Mass	-	74.15	g
	Height of Water	2.63	-	cm
	Primary Swell	-	11.2%	%
	Ultimate Swell	-	11.3%	%

Primary Swell (%)	11.2%		Ultimate Swell (%)	11.3%
Slope of Primary Swelling	3.71%	% per log cycle	Time to Swell (hr)	62.31
Slope of Secondary Swelling	0.51%	% per log cycle	Stress (psf)	100

NOTES	

Date test conducted	2/23/2018	
Centrifuge used	3	
Cup Number	4	
Conducted by	Karly	



SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

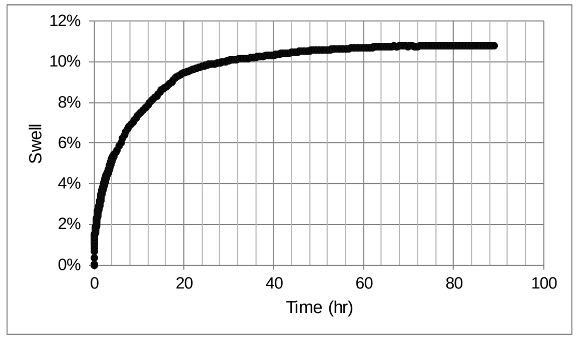
TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.97	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	38.04	37.97	g
	Dry Unit Weight	14.66	14.66	kN/m3
	Height of Sample	1.000	1.013	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.018	cm
	Testing Height	1.008	1.131	cm
	Void Ratio, e	0.834	1.058	-
	Moisture Content	24.4%	43.0%	%
	Saturation	80.1%	100.0%	%
	Change in Moisture Content	-	18.6%	%
	Overburden Mass	-	73.53	g
	Height of Water	2.62	-	cm
	Primary Swell	-	10.8%	%
	Ultimate Swell	-	12.2%	%

Primary Swell (%)	10.8%		Ultimate Swell (%)	12.2%
Slope of Primary Swelling	6.63%	% per log cycle	Time to Swell (hr)	8.64
Slope of Secondary Swelling	0.96%	% per log cycle	Stress (psf)	99

NOTES	

Date test conducted	2/23/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly



SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

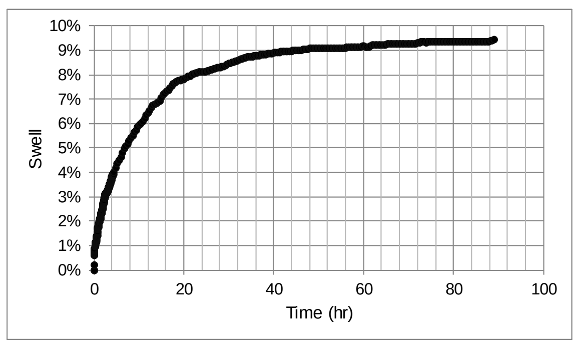
TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.97	gravity
	Initial Moisture Content	24.0%	24.7%	%
	Mass Soil Added	38.06	38.02	g
	Dry Unit Weight	14.84	14.82	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.047	cm
	Testing Height	0.996	1.103	cm
	Void Ratio, e	0.813	1.010	-
	Moisture Content	24.7%	39.9%	%
	Saturation	83.2%	100.0%	%
	Change in Moisture Content	-	15.2%	%
	Overburden Mass	-	139.98	g
	Height of Water	2.63	-	cm
	Primary Swell	-	9.9%	%
	Ultimate Swell	-	10.8%	%

Primary Swell (%)	9.9%	Ultimate Swell (%)	10.8%
Slope of Primary Swelling	5.45% % per log cycle	Time to Swell (hr)	25.54
Slope of Secondary Swelling	1.50% % per log cycle	Stress (psf)	169

NOTES	

Date test conducted	2/23/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly



SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.97	gravity
	Initial Moisture Content	24.0%	24.7%	%
	Mass Soil Added	38.05	38.02	g
	Dry Unit Weight	14.54	14.53	kN/m3
	Height of Sample	1.000	1.022	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.054	cm
	Testing Height	1.015	1.111	cm
	Void Ratio, e	0.850	1.024	-
	Moisture Content	24.7%	41.7%	%
	Saturation	79.8%	100.0%	%
	Change in Moisture Content	-	17.0%	%
	Overburden Mass	-	139.65	g
	Height of Water	2.62	-	cm
	Primary Swell	-	8.4%	%
	Ultimate Swell	-	9.4%	%

Primary Swell (%)	8.4%	Ultimate Swell (%)	9.4%
Slope of Primary Swelling	4.93% % per log cycle	Time to Swell (hr)	28.88
Slope of Secondary Swelling	1.50% % per log cycle	Stress (psf)	169

NOTES	

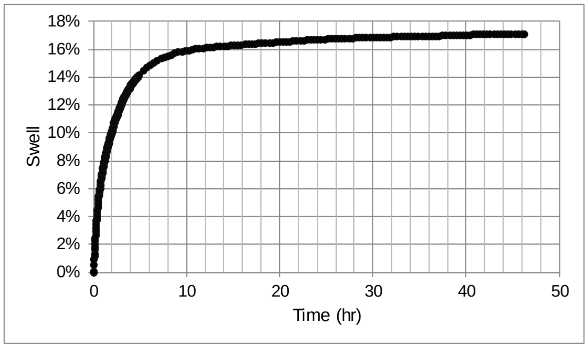
Date test conducted	3/20/2018	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	12.36	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.07	37.95	g
	Dry Unit Weight	14.76	14.76	kN/m3
	Height of Sample	1.000	1.007	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.445	cm
	Testing Height	1.007	1.179	cm
	Void Ratio, e	0.821	1.132	-
	Moisture Content	23.6%	45.8%	%
	Saturation	78.7%	100.0%	%
	Change in Moisture Content	-	22.2%	%
	Overburden Mass	-	40.55	g
	Height of Water	2.62	-	cm
	Primary Swell	-	15.7%	%
	Ultimate Swell	-	17.1%	%

NOTES	



Primary Swell (%)	15.7%		Ultimate Swell (%)	17.1%
Slope of Primary Swelling	8.55%	% per log cycle	Time to Swell (hr)	8.75
Slope of Secondary Swelling	1.87%	% per log cycle	Stress (psf)	73

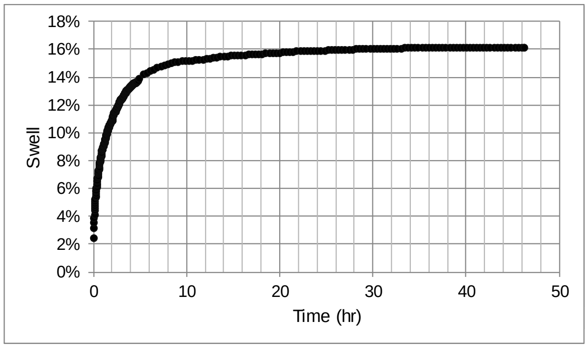
Date test conducted	3/20/2018	
Centrifuge used	3	
Cup Number	3	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	12.36	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.07	38.02	g
	Dry Unit Weight	14.68	14.75	kN/m3
	Height of Sample	1.000	1.012	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.095	cm
	Testing Height	1.009	1.172	cm
	Void Ratio, e	0.822	1.116	-
	Moisture Content	23.6%	43.6%	%
	Saturation	78.8%	100.0%	%
	Change in Moisture Content	-	20.0%	%
	Overburden Mass	-	73.09	g
	Height of Water	2.62	-	cm
	Primary Swell	-	14.9%	%
	Ultimate Swell	-	16.1%	%

NOTES	



Primary Swell (%)	14.9%		Ultimate Swell (%)	16.1%
Slope of Primary Swelling	6.43%	% per log cycle	Time to Swell (hr)	7.99
Slope of Secondary Swelling	1.66%	% per log cycle	Stress (psf)	112

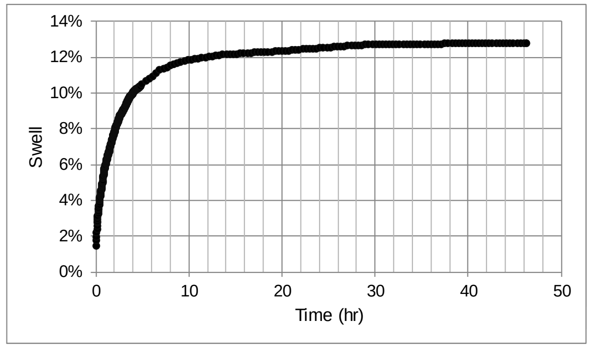
Date test conducted	3/20/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	10.00	12.36	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.06	38.01	g
	Dry Unit Weight	14.76	14.81	kN/m3
	Height of Sample	1.000	1.006	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.021	cm
	Testing Height	1.005	1.133	cm
	Void Ratio, e	0.815	1.047	-
	Moisture Content	23.6%	40.8%	%
	Saturation	79.4%	100.0%	%
	Change in Moisture Content	-	17.2%	%
	Overburden Mass	-	142.54	g
	Height of Water	2.62	-	cm
	Primary Swell	-	11.9%	%
	Ultimate Swell	-	12.8%	%

NOTES	



Primary Swell (%)	11.9%	
Ultimate Swell (%)	12.8%	
Slope of Primary Swelling	5.34%	% per log cycle
Time to Swell (hr)	10.25	
Slope of Secondary Swelling	1.59%	% per log cycle
Stress (psf)	194	

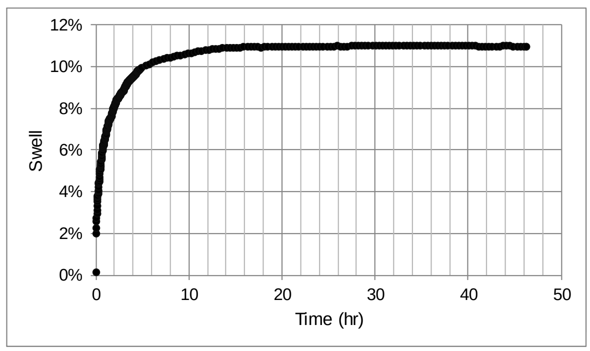
Date test conducted	3/20/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	10.00	12.36	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.09	38.04	g
	Dry Unit Weight	14.59	14.64	kN/m3
	Height of Sample	1.000	1.019	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.053	cm
	Testing Height	1.016	1.128	cm
	Void Ratio, e	0.836	1.039	-
	Moisture Content	23.7%	41.6%	%
	Saturation	77.8%	100.0%	%
	Change in Moisture Content	-	17.9%	%
	Overburden Mass	-	140.85	g
	Height of Water	2.62	-	cm
	Primary Swell	-	10.3%	%
	Ultimate Swell	-	11.0%	%

NOTES	



Primary Swell (%)	10.3%	
Ultimate Swell (%)	11.0%	
Slope of Primary Swelling	4.66%	% per log cycle
Time to Swell (hr)	6.86	
Slope of Secondary Swelling	0.70%	% per log cycle
Stress (psf)	192	

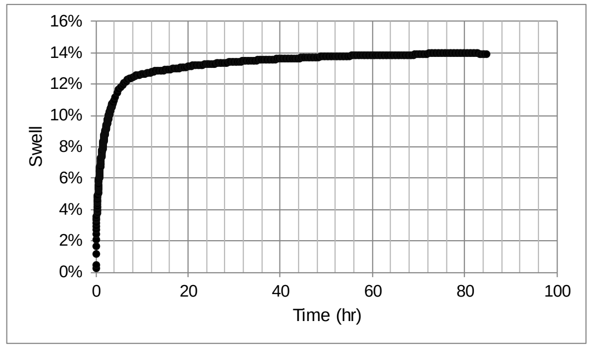
Date test conducted	4/20/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	34.87	gravity
	Initial Moisture Content	24.0%	23.0%	%
	Mass Soil Added	38.05	37.91	g
	Dry Unit Weight	14.54	14.91	kN/m3
	Height of Sample	1.000	1.022	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.007	cm
	Testing Height	1.000	1.140	cm
	Void Ratio, e	0.803	1.054	-
	Moisture Content	23.0%	43.9%	%
	Saturation	78.5%	100.0%	%
	Change in Moisture Content	-	20.9%	%
	Overburden Mass	-	40.34	g
	Height of Water	2.62	-	cm
	Primary Swell	-	12.3%	%
	Ultimate Swell	-	14.0%	%

NOTES	



Primary Swell (%)	12.3%	Ultimate Swell (%)	14.0%
Slope of Primary Swelling	6.42% % per log cycle	Time to Swell (hr)	6.88
Slope of Secondary Swelling	1.53% % per log cycle	Stress (psf)	203

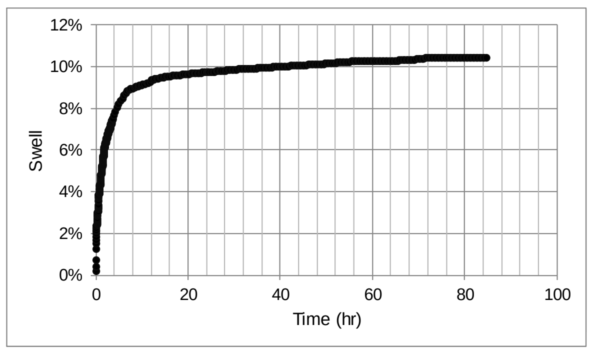
Date test conducted	4/20/2018
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	34.87	gravity
	Initial Moisture Content	24.0%	23.0%	%
	Mass Soil Added	38.05	37.92	g
	Dry Unit Weight	14.67	15.08	kN/m3
	Height of Sample	1.000	1.012	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.000	cm
	Testing Height	0.990	1.093	cm
	Void Ratio, e	0.782	0.968	-
	Moisture Content	23.0%	44.2%	%
	Saturation	80.4%	100.0%	%
	Change in Moisture Content	-	21.2%	%
	Overburden Mass	-	40.08	g
	Height of Water	2.62	-	cm
	Primary Swell	-	9.0%	%
	Ultimate Swell	-	10.4%	%

NOTES	



Primary Swell (%)	9.0%	Ultimate Swell (%)	10.4%
Slope of Primary Swelling	4.89% % per log cycle	Time to Swell (hr)	8.01
Slope of Secondary Swelling	1.37% % per log cycle	Stress (psf)	201

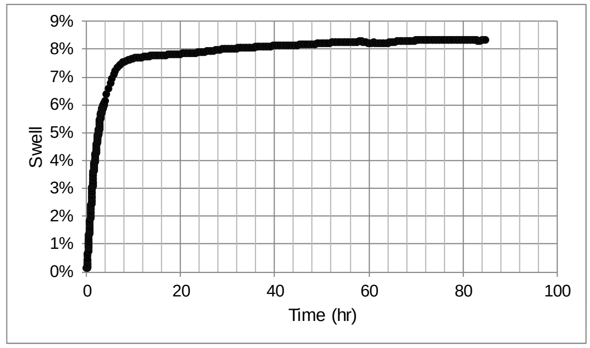
Date test conducted	4/20/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	34.87	gravity
	Initial Moisture Content	24.0%	23.3%	%
	Mass Soil Added	38.05	37.94	g
	Dry Unit Weight	14.54	14.82	kN/m3
	Height of Sample	1.000	1.022	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.000	cm
	Testing Height	1.005	1.089	cm
	Void Ratio, e	0.814	0.965	-
	Moisture Content	23.3%	42.6%	%
	Saturation	78.6%	100.0%	%
	Change in Moisture Content	-	19.3%	%
	Overburden Mass	-	74.21	g
	Height of Water	2.63	-	cm
	Primary Swell	-	7.4%	%
	Ultimate Swell	-	8.3%	%

NOTES	



Primary Swell (%)	7.4%		Ultimate Swell (%)	8.3%
Slope of Primary Swelling	5.68%	% per log cycle	Time to Swell (hr)	6.88
Slope of Secondary Swelling	0.88%	% per log cycle	Stress (psf)	317

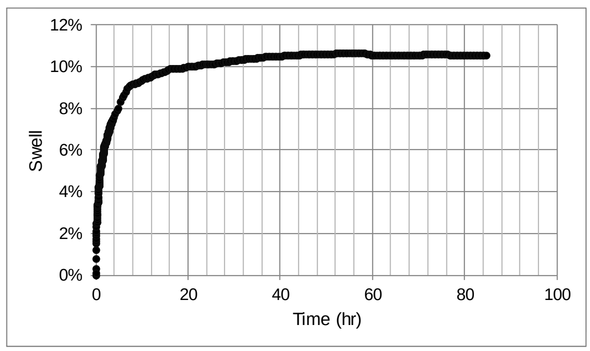
Date test conducted	4/20/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	34.87	gravity
	Initial Moisture Content	24.0%	22.7%	%
	Mass Soil Added	38.05	37.96	g
	Dry Unit Weight	14.55	14.89	kN/m3
	Height of Sample	1.000	1.021	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.026	cm
	Testing Height	1.005	1.112	cm
	Void Ratio, e	0.805	0.997	-
	Moisture Content	22.7%	39.2%	%
	Saturation	77.4%	100.0%	%
	Change in Moisture Content	-	16.5%	%
	Overburden Mass	-	74.02	g
	Height of Water	2.62	-	cm
	Primary Swell	-	9.4%	%
	Ultimate Swell	-	10.6%	%

NOTES	



Primary Swell (%)	9.4%		Ultimate Swell (%)	10.6%
Slope of Primary Swelling	4.29%	% per log cycle	Time to Swell (hr)	11.02
Slope of Secondary Swelling	1.85%	% per log cycle	Stress (psf)	317

Date test conducted	9/10/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

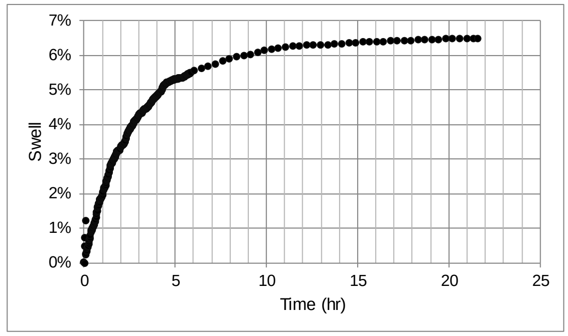
2

SOIL Information		
	Soil	EF 24%
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	72.30	gravity
	Initial Moisture Content	24.0%	25.7%	%
	Mass Soil Added	38.07	37.92	g
	Dry Unit Weight	14.65	14.57	kN/m3
	Height of Sample	1.000	1.014	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.050	cm
	Testing Height	1.002	1.067	cm
	Void Ratio, e	0.818	0.936	-
	Moisture Content	25.7%	39.1%	%
	Saturation	84.9%	100.0%	%
	Change in Moisture Content	-	13.4%	%
	Overburden Mass	-	39.39	g
	Height of Water	2.23	-	cm
	Primary Swell	-	5.8%	%
	Ultimate Swell	-	6.5%	%

NOTES	



Primary Swell (%)	5.8%		Ultimate Swell (%)	6.5%
Slope of Primary Swelling	4.60%	% per log cycle	Time to Swell (hr)	7.58
Slope of Secondary Swelling	0.89%	% per log cycle	Stress (psf)	410

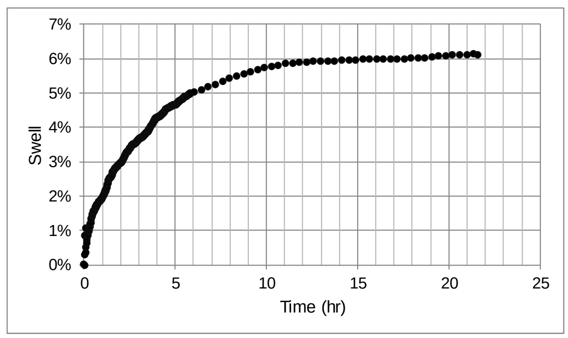
Date test conducted	9/10/2017
Centrifuge used	='Data Sheets'!I$1
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF 24%
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	72.30	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	37.97	37.90	g
	Dry Unit Weight	14.48	14.80	kN/m3
	Height of Sample	1.000	1.024	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.047	cm
	Testing Height	0.998	1.060	cm
	Void Ratio, e	0.790	0.899	-
	Moisture Content	24.1%	38.7%	%
	Saturation	82.5%	100.0%	%
	Change in Moisture Content	-	14.6%	%
	Overburden Mass	-	40.25	g
	Height of Water	2.29	-	cm
	Primary Swell	-	5.9%	%
	Ultimate Swell	-	6.1%	%

NOTES	



Primary Swell (%)	5.9%		Ultimate Swell (%)	6.1%
Slope of Primary Swelling	3.64%	% per log cycle	Time to Swell (hr)	11.82
Slope of Secondary Swelling	0.94%	% per log cycle	Stress (psf)	416

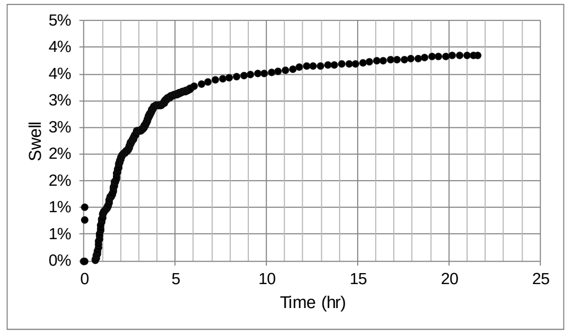
Date test conducted	9/10/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	EF 24%
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	75.00	72.30	gravity
	Initial Moisture Content	24.0%	25.5%	%
	Mass Soil Added	38.00	37.94	g
	Dry Unit Weight	14.64	14.78	kN/m3
	Height of Sample	1.000	1.013	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.073	cm
	Testing Height	0.990	1.028	cm
	Void Ratio, e	0.792	0.861	-
	Moisture Content	25.5%	37.4%	%
	Saturation	87.1%	100.0%	%
	Change in Moisture Content	-	11.8%	%
	Overburden Mass	-	74.24	g
	Height of Water	2.28	-	cm
	Primary Swell	-	3.1%	%
	Ultimate Swell	-	3.9%	%

NOTES	



Primary Swell (%)	3.1%	Ultimate Swell (%)	3.9%
Slope of Primary Swelling	3.61% % per log cycle	Time to Swell (hr)	4.86
Slope of Secondary Swelling	1.00% % per log cycle	Stress (psf)	654

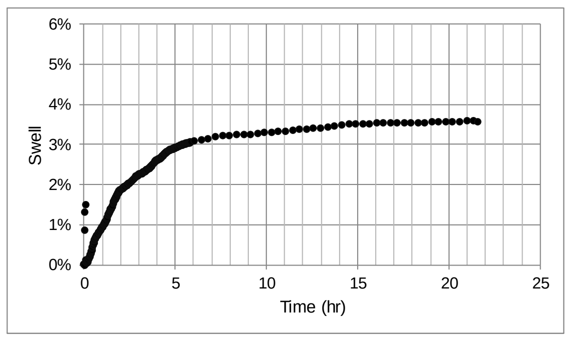
Date test conducted	9/10/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information	Soil	EF 24%
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	75.00	72.30	gravity
	Initial Moisture Content	24.0%	24.5%	%
	Mass Soil Added	38.00	37.90	g
	Dry Unit Weight	14.57	15.18	kN/m3
	Height of Sample	1.000	1.018	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.078	cm
	Testing Height	0.971	1.005	cm
	Void Ratio, e	0.745	0.808	-
	Moisture Content	24.5%	38.1%	%
	Saturation	88.8%	100.0%	%
	Change in Moisture Content	-	13.6%	%
	Overburden Mass	-	75.59	g
	Height of Water	2.30	-	cm
	Primary Swell	-	3.1%	%
	Ultimate Swell	-	3.6%	%

NOTES	



Primary Swell (%)	3.1%	Ultimate Swell (%)	3.6%
Slope of Primary Swelling	2.64% % per log cycle	Time to Swell (hr)	6.81
Slope of Secondary Swelling	0.89% % per log cycle	Stress (psf)	663

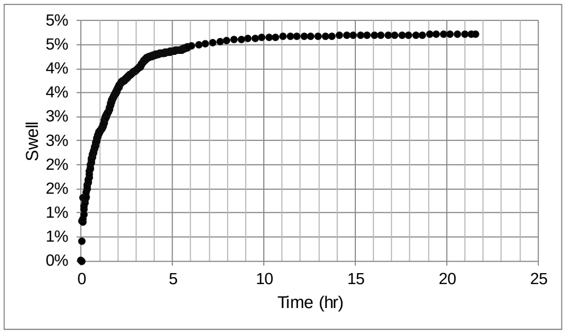
Date test conducted	9/10/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF 24%
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	75.00	72.30	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	38.02	37.99	g
	Dry Unit Weight	14.56	14.86	kN/m3
	Height of Sample	1.000	1.019	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.078	cm
	Testing Height	0.998	1.046	cm
	Void Ratio, e	0.782	0.866	-
	Moisture Content	23.9%	36.1%	%
	Saturation	82.6%	100.0%	%
	Change in Moisture Content	-	12.2%	%
	Overburden Mass	-	141.52	g
	Height of Water	2.29	-	cm
	Primary Swell	-	4.4%	%
	Ultimate Swell	-	4.7%	%

NOTES	



Primary Swell (%)	4.4%	Ultimate Swell (%)	4.7%
Slope of Primary Swelling	2.69% % per log cycle	Time to Swell (hr)	5.08
Slope of Secondary Swelling	0.20% % per log cycle	Stress (psf)	1126

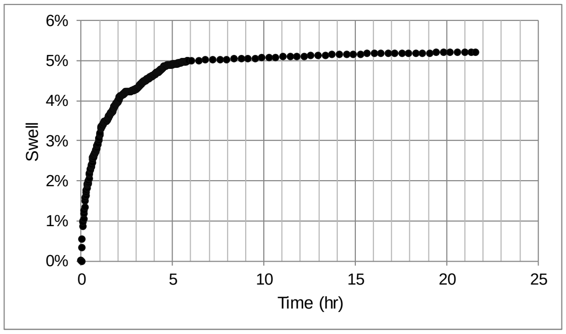
Date test conducted	9/10/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF 24%
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	75.00	72.30	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	37.98	37.93	g
	Dry Unit Weight	14.73	14.91	kN/m3
	Height of Sample	1.000	1.006	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.030	cm
	Testing Height	0.990	1.042	cm
	Void Ratio, e	0.776	0.869	-
	Moisture Content	24.4%	35.6%	%
	Saturation	84.8%	100.0%	%
	Change in Moisture Content	-	11.3%	%
	Overburden Mass	-	141.10	g
	Height of Water	2.29	-	cm
	Primary Swell	-	4.9%	%
	Ultimate Swell	-	5.2%	%

NOTES	



Primary Swell (%)	4.9%	Ultimate Swell (%)	5.2%
Slope of Primary Swelling	2.73% % per log cycle	Time to Swell (hr)	5.06
Slope of Secondary Swelling	0.43% % per log cycle	Stress (psf)	1123

0

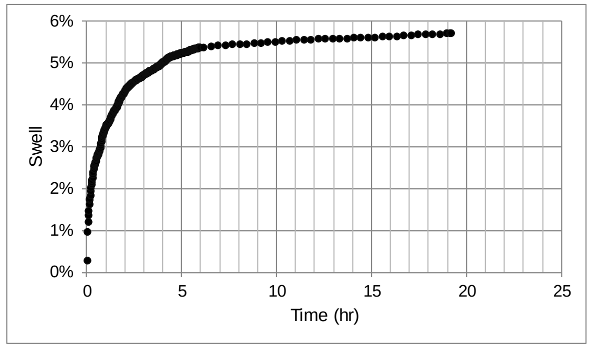
	Date test conducted	10/30/2017
	Centrifuge used	3
	Cup Number	1
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	175.00	182.53	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	37.99	37.90	g
	Dry Unit Weight	14.61	12.71	kN/m3
	Height of Sample	1.000	1.015	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.087	cm
	Testing Height	1.166	1.232	cm
	Void Ratio, e	1.115	1.236	-
	Moisture Content	23.8%	35.2%	%
	Saturation	58.5%	78.0%	%
	Change in Moisture Content	-	11.4%	%
	Overburden Mass	-	39.48	g
	Height of Water	2.25	-	cm
	Primary Swell	-	5.3%	%
	Ultimate Swell	-	5.7%	%

NOTES	



Primary Swell (%)	5.3%		Ultimate Swell (%)	5.7%
Slope of Primary Swelling	2.62%	% per log cycle	Time to Swell (hr)	5.20
Slope of Secondary Swelling	0.64%	% per log cycle	Stress (psf)	1060

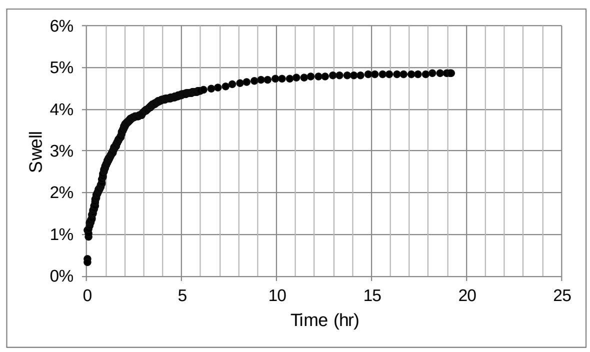
	Date test conducted	10/30/2017
	Centrifuge used	3
	Cup Number	2
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	175.00	182.53	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	38.03	37.95	g
	Dry Unit Weight	14.58	12.78	kN/m3
	Height of Sample	1.000	1.018	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.943	cm
	Testing Height	1.161	1.218	cm
	Void Ratio, e	1.103	1.206	-
	Moisture Content	23.8%	35.9%	%
	Saturation	59.1%	81.5%	%
	Change in Moisture Content	-	12.1%	%
	Overburden Mass	-	39.95	g
	Height of Water	2.24	-	cm
	Primary Swell	-	4.3%	%
	Ultimate Swell	-	4.9%	%

NOTES	



Primary Swell (%)	4.3%		Ultimate Swell (%)	4.9%
Slope of Primary Swelling	2.62%	% per log cycle	Time to Swell (hr)	4.50
Slope of Secondary Swelling	0.79%	% per log cycle	Stress (psf)	1066

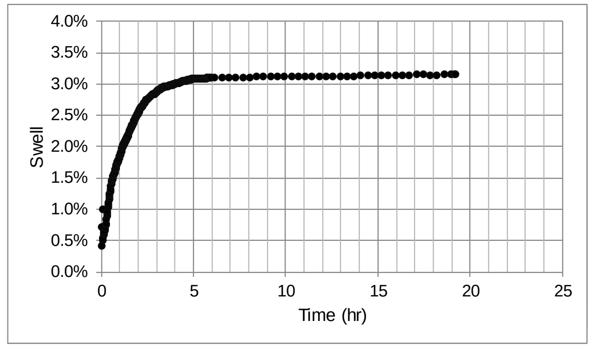
Date test conducted	10/30/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	175.00	182.53	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.02	37.99	g
	Dry Unit Weight	14.58	15.44	kN/m3
	Height of Sample	1.000	1.018	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.014	cm
	Testing Height	0.963	0.993	cm
	Void Ratio, e	0.741	0.796	-
	Moisture Content	23.7%	34.0%	%
	Saturation	87.7%	100.0%	%
	Change in Moisture Content	-	10.3%	%
	Overburden Mass	-	75.67	g
	Height of Water	2.27	-	cm
	Primary Swell	-	3.0%	%
	Ultimate Swell	-	3.2%	%

NOTES	



Primary Swell (%)	3.0%		Ultimate Swell (%)	3.2%
Slope of Primary Swelling	2.02%	% per log cycle	Time to Swell (hr)	3.75
Slope of Secondary Swelling	0.12%	% per log cycle	Stress (psf)	1678

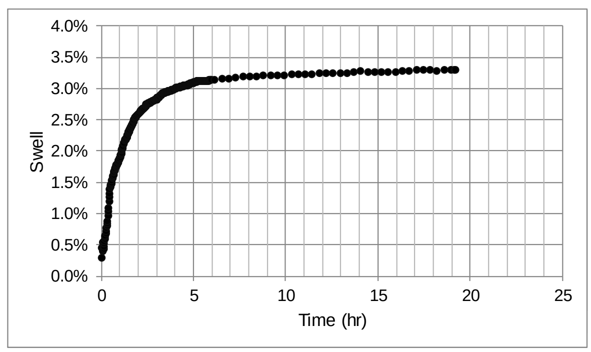
Date test conducted	10/30/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	175.00	182.53	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	37.97	37.94	g
	Dry Unit Weight	14.50	14.97	kN/m3
	Height of Sample	1.000	1.022	cm

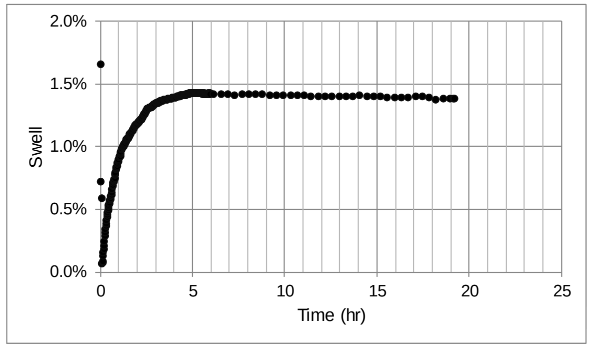
TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.042	cm
	Testing Height	0.991	1.023	cm
	Void Ratio, e	0.796	0.855	-
	Moisture Content	23.9%	34.6%	%
	Saturation	82.2%	100.0%	%
	Change in Moisture Content	-	10.8%	%
	Overburden Mass	-	73.90	g
	Height of Water	2.31	-	cm
	Primary Swell	-	3.0%	%
	Ultimate Swell	-	3.3%	%

NOTES	



Primary Swell (%)	3.0%		Ultimate Swell (%)	3.3%
Slope of Primary Swelling	1.80%	% per log cycle	Time to Swell (hr)	4.16
Slope of Secondary Swelling	0.34%	% per log cycle	Stress (psf)	1648

Date test conducted	10/30/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly



SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

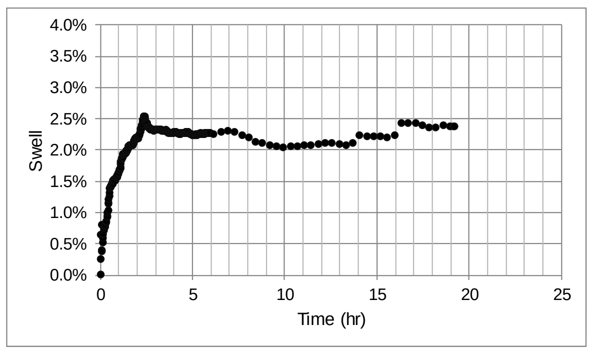
TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	175.00	182.53	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	37.98	37.92	g
	Dry Unit Weight	14.56	15.47	kN/m3
	Height of Sample	1.000	1.018	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.046	cm
	Testing Height	0.956	0.970	cm
	Void Ratio, e	0.738	0.763	-
	Moisture Content	24.1%	32.4%	%
	Saturation	89.6%	100.0%	%
	Change in Moisture Content	-	8.3%	%
	Overburden Mass	-	140.58	g
	Height of Water	2.30	-	cm
	Primary Swell	-	1.4%	%
	Ultimate Swell	-	1.4%	%

Primary Swell (%)	1.4%		Ultimate Swell (%)	1.4%
Slope of Primary Swelling	1.02%	% per log cycle	Time to Swell (hr)	3.61
Slope of Secondary Swelling	-0.05%	% per log cycle	Stress (psf)	2825

NOTES	

Date test conducted	10/30/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly



SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	175.00	182.53	gravity
	Initial Moisture Content	24.0%	24.2%	%
	Mass Soil Added	37.95	37.93	g
	Dry Unit Weight	14.65	15.60	kN/m3
	Height of Sample	1.000	1.011	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.030	cm
	Testing Height	0.948	0.972	cm
	Void Ratio, e	0.724	0.767	-
	Moisture Content	24.2%	33.3%	%
	Saturation	91.5%	100.0%	%
	Change in Moisture Content	-	9.1%	%
	Overburden Mass	-	141.16	g
	Height of Water	2.25	-	cm
	Primary Swell	-	2.2%	%
	Ultimate Swell	-	2.5%	%

Primary Swell (%)	2.2%		Ultimate Swell (%)	2.5%
Slope of Primary Swelling	1.34%	% per log cycle	Time to Swell (hr)	1.92
Slope of Secondary Swelling	0.39%	% per log cycle	Stress (psf)	2835

NOTES	

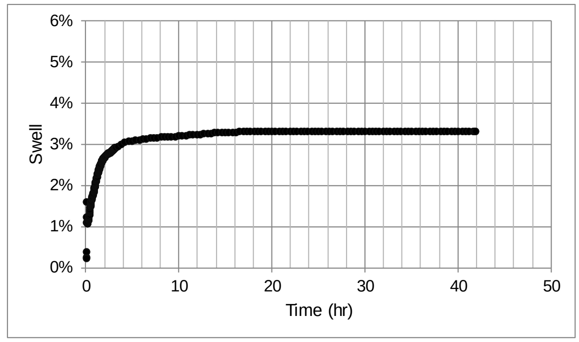
Date test conducted	11/13/2017
Centrifuge used	1
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	256.21	gravity
	Initial Moisture Content	24.0%	23.3%	%
	Mass Soil Added	38.01	37.81	g
	Dry Unit Weight	14.60	15.33	kN/m3
	Height of Sample	1.000	1.017	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.002	cm
	Testing Height	0.968	1.000	cm
	Void Ratio, e	0.753	0.812	-
	Moisture Content	23.3%	35.1%	%
	Saturation	84.8%	100.0%	%
	Change in Moisture Content	-	11.8%	%
	Overburden Mass	-	40.93	g
	Height of Water	2.44	-	cm
	Primary Swell	-	3.0%	%
	Ultimate Swell	-	3.3%	%

NOTES	



Primary Swell (%)	3.0%		Ultimate Swell (%)	3.3%
Slope of Primary Swelling	1.85%	% per log cycle	Time to Swell (hr)	4.19
Slope of Secondary Swelling	0.05%	% per log cycle	Stress (psf)	1485

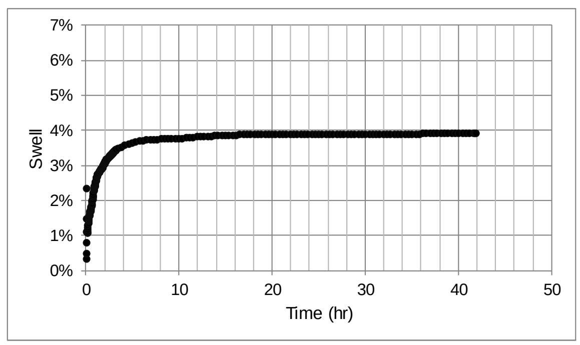
Date test conducted	11/13/2017
Centrifuge used	1
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	256.21	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.01	37.92	g
	Dry Unit Weight	14.60	15.44	kN/m3
	Height of Sample	1.000	1.017	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.020	cm
	Testing Height	0.963	1.000	cm
	Void Ratio, e	0.741	0.809	-
	Moisture Content	23.5%	34.8%	%
	Saturation	86.8%	100.0%	%
	Change in Moisture Content	-	11.4%	%
	Overburden Mass	-	40.08	g
	Height of Water	2.44	-	cm
	Primary Swell	-	3.6%	%
	Ultimate Swell	-	3.9%	%

NOTES	



Primary Swell (%)	3.6%		Ultimate Swell (%)	3.9%
Slope of Primary Swelling	1.98%	% per log cycle	Time to Swell (hr)	4.96
Slope of Secondary Swelling	0.06%	% per log cycle	Stress (psf)	1465

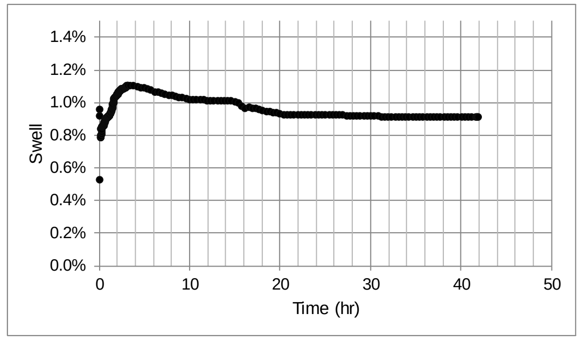
Date test conducted	11/13/2017
Centrifuge used	1
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	250.00	256.21	gravity
	Initial Moisture Content	24.0%	23.3%	%
	Mass Soil Added	38.04	38.03	g
	Dry Unit Weight	14.75	15.43	kN/m3
	Height of Sample	1.000	1.006	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.015	cm
	Testing Height	0.968	0.978	cm
	Void Ratio, e	0.742	0.762	-
	Moisture Content	23.3%	32.1%	%
	Saturation	86.0%	100.0%	%
	Change in Moisture Content	-	8.8%	%
	Overburden Mass	-	140.58	g
	Height of Water	2.44	-	cm
	Primary Swell	-	1.1%	%
	Ultimate Swell	-	1.1%	%

NOTES	='Data Sheets'!AD73:AG74



Primary Swell (%)	1.1%		Ultimate Swell (%)	1.1%
Slope of Primary Swelling	0.21%	% per log cycle	Time to Swell (hr)	2.72
Slope of Secondary Swelling	-0.12%	% per log cycle	Stress (psf)	3968

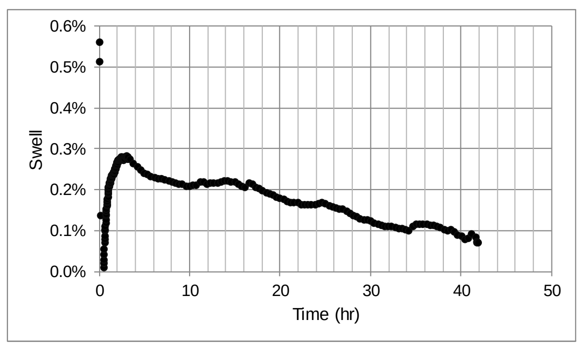
Date test conducted	11/13/2017
Centrifuge used	1
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	250.00	256.21	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.04	38.05	g
	Dry Unit Weight	14.56	15.77	kN/m3
	Height of Sample	1.000	1.020	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.035	cm
	Testing Height	0.945	0.947	cm
	Void Ratio, e	0.704	0.709	-
	Moisture Content	23.6%	31.9%	%
	Saturation	91.9%	100.0%	%
	Change in Moisture Content	-	8.3%	%
	Overburden Mass	-	141.88	g
	Height of Water	2.45	-	cm
	Primary Swell	-	0.3%	%
	Ultimate Swell	-	0.3%	%

NOTES	



Primary Swell (%)	0.3%		Ultimate Swell (%)	0.3%
Slope of Primary Swelling	0.48%	% per log cycle	Time to Swell (hr)	3.42
Slope of Secondary Swelling	-0.28%	% per log cycle	Stress (psf)	3998

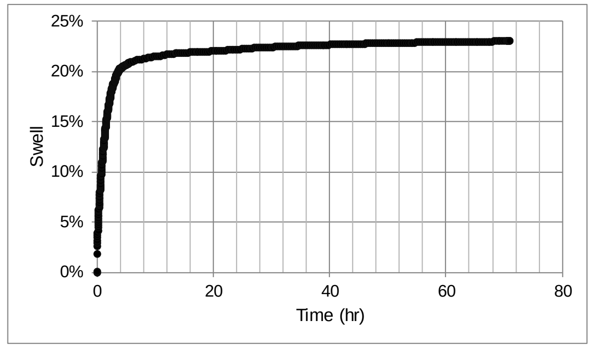
Date test conducted	4/13/2018
Centrifuge used	1
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	17%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	9.94	gravity
	Initial Moisture Content	24.0%	17.1%	%
	Mass Soil Added	37.03	36.96	g
	Dry Unit Weight	14.19	14.99	kN/m3
	Height of Sample	1.000	1.019	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.012	cm
	Testing Height	1.018	1.253	cm
	Void Ratio, e	0.793	1.206	-
	Moisture Content	17.1%	47.3%	%
	Saturation	59.3%	100.0%	%
	Change in Moisture Content	-	30.1%	%
	Overburden Mass	-	73.66	g
	Height of Water	2.62	-	cm
	Primary Swell	-	19.4%	%
	Ultimate Swell	-	23.0%	%

NOTES	



Primary Swell (%)	19.4%		Ultimate Swell (%)	23.0%
Slope of Primary Swelling	16.28%	% per log cycle	Time to Swell (hr)	3.25
Slope of Secondary Swelling	2.83%	% per log cycle	Stress (psf)	91

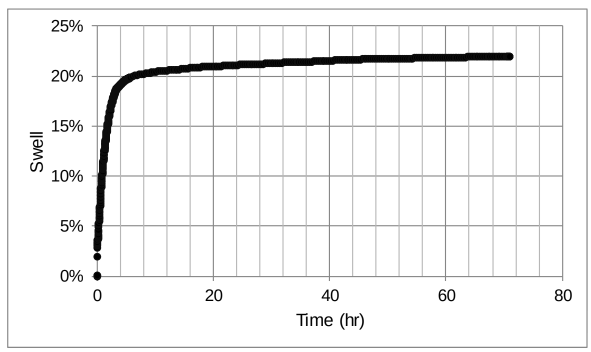
Date test conducted	4/13/2018
Centrifuge used	1
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	17%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	9.94	gravity
	Initial Moisture Content	24.0%	17.1%	%
	Mass Soil Added	37.05	36.98	g
	Dry Unit Weight	14.26	15.06	kN/m3
	Height of Sample	1.000	1.014	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.008	cm
	Testing Height	1.015	1.238	cm
	Void Ratio, e	0.785	1.177	-
	Moisture Content	17.1%	47.7%	%
	Saturation	59.8%	100.0%	%
	Change in Moisture Content	-	30.6%	%
	Overburden Mass	-	73.63	g
	Height of Water	2.62	-	cm
	Primary Swell	-	18.1%	%
	Ultimate Swell	-	22.0%	%

NOTES	



Primary Swell (%)	18.1%		Ultimate Swell (%)	22.0%
Slope of Primary Swelling	16.87%	% per log cycle	Time to Swell (hr)	2.98
Slope of Secondary Swelling	2.84%	% per log cycle	Stress (psf)	91

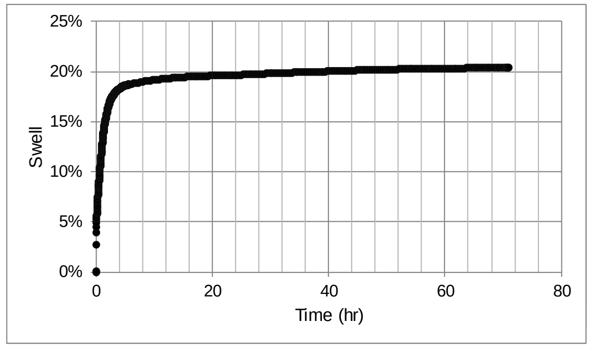
Date test conducted	4/13/2018	
Centrifuge used	1	
Cup Number	3	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	19%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	9.94	gravity
	Initial Moisture Content	24.0%	19.3%	%
	Mass Soil Added	36.39	36.34	g
	Dry Unit Weight	13.95	14.48	kN/m3
	Height of Sample	1.000	1.019	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.024	cm
	Testing Height	1.018	1.227	cm
	Void Ratio, e	0.857	1.236	-
	Moisture Content	19.3%	48.4%	%
	Saturation	61.7%	100.0%	%
	Change in Moisture Content	-	29.1%	%
	Overburden Mass	-	73.73	g
	Height of Water	2.63	-	cm
	Primary Swell	-	17.3%	%
	Ultimate Swell	-	20.4%	%

NOTES	



Primary Swell (%)	17.3%		Ultimate Swell (%)	20.4%
Slope of Primary Swelling	13.85%	% per log cycle	Time to Swell (hr)	2.62
Slope of Secondary Swelling	2.00%	% per log cycle	Stress (psf)	90

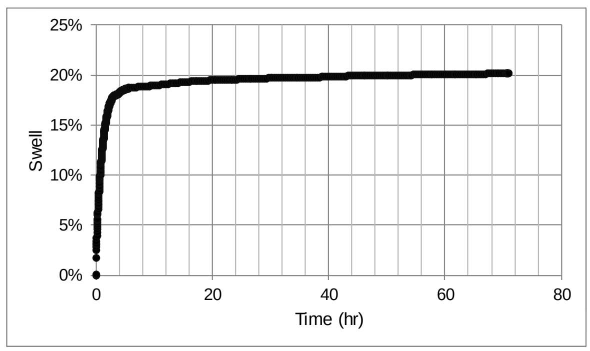
Date test conducted	4/13/2018	
Centrifuge used	1	
Cup Number	4	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	19%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	9.94	gravity
	Initial Moisture Content	24.0%	19.4%	%
	Mass Soil Added	36.39	36.35	g
	Dry Unit Weight	13.94	14.46	kN/m3
	Height of Sample	1.000	1.019	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.008	cm
	Testing Height	1.019	1.225	cm
	Void Ratio, e	0.859	1.233	-
	Moisture Content	19.4%	48.0%	%
	Saturation	61.8%	100.0%	%
	Change in Moisture Content	-	28.6%	%
	Overburden Mass	-	73.12	g
	Height of Water	2.61	-	cm
	Primary Swell	-	17.3%	%
	Ultimate Swell	-	20.2%	%

NOTES	



Primary Swell (%)	17.3%		Ultimate Swell (%)	20.2%
Slope of Primary Swelling	14.69%	% per log cycle	Time to Swell (hr)	2.53
Slope of Secondary Swelling	1.96%	% per log cycle	Stress (psf)	90

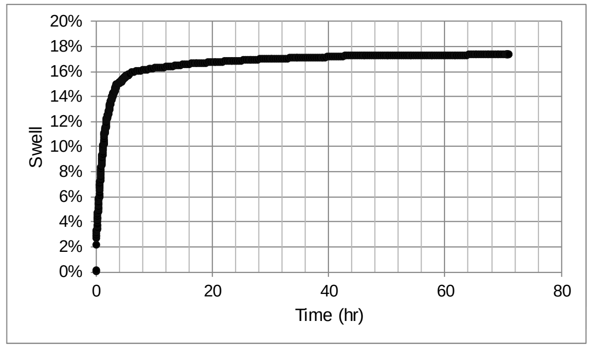
Date test conducted	4/13/2018	
Centrifuge used	1	
Cup Number	5	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	10.00	9.94	gravity
	Initial Moisture Content	24.0%	21.6%	%
	Mass Soil Added	37.05	37.02	g
	Dry Unit Weight	14.18	14.44	kN/m3
	Height of Sample	1.000	1.020	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.060	cm
	Testing Height	1.020	1.198	cm
	Void Ratio, e	0.861	1.185	-
	Moisture Content	21.6%	47.5%	%
	Saturation	68.8%	100.0%	%
	Change in Moisture Content	-	25.9%	%
	Overburden Mass	-	74.22	g
	Height of Water	2.61	-	cm
	Primary Swell	-	14.3%	%
	Ultimate Swell	-	17.4%	%

NOTES	



Primary Swell (%)	14.3%	
Slope of Primary Swelling	12.47%	% per log cycle
Slope of Secondary Swelling	2.39%	% per log cycle

Ultimate Swell (%)	17.4%
Time to Swell (hr)	3.09
Stress (psf)	91

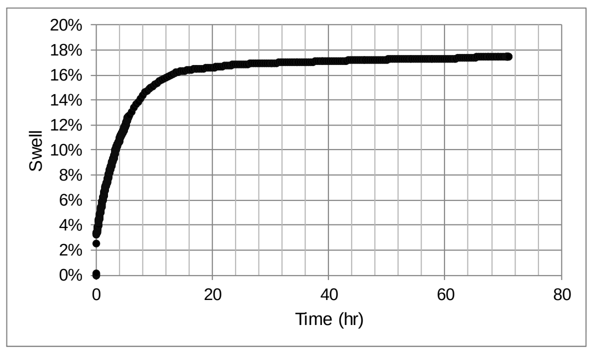
Date test conducted	4/13/2018	
Centrifuge used	1	
Cup Number	6	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	21%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	10.00	9.94	gravity
	Initial Moisture Content	24.0%	21.4%	%
	Mass Soil Added	37.03	37.01	g
	Dry Unit Weight	14.17	14.46	kN/m3
	Height of Sample	1.000	1.020	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.048	cm
	Testing Height	1.020	1.198	cm
	Void Ratio, e	0.859	1.183	-
	Moisture Content	21.4%	46.9%	%
	Saturation	68.4%	100.0%	%
	Change in Moisture Content	-	25.5%	%
	Overburden Mass	-	75.25	g
	Height of Water	2.61	-	cm
	Primary Swell	-	15.9%	%
	Ultimate Swell	-	17.5%	%

NOTES	



Primary Swell (%)	15.9%	
Slope of Primary Swelling	10.92%	% per log cycle
Slope of Secondary Swelling	1.61%	% per log cycle

Ultimate Swell (%)	17.5%
Time to Swell (hr)	12.39
Stress (psf)	92

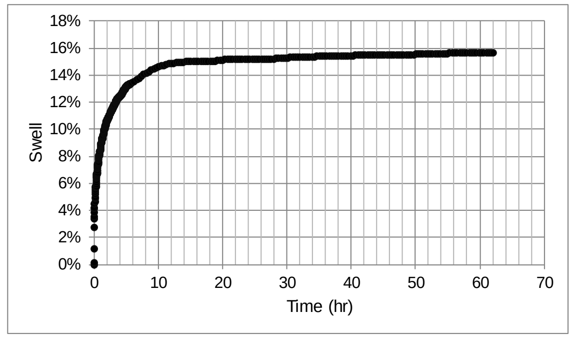
Date test conducted	3/2/2018
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.74	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	38.06	37.99	g
	Dry Unit Weight	14.75	14.67	kN/m3
	Height of Sample	1.000	1.007	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.095	cm
	Testing Height	1.004	1.161	cm
	Void Ratio, e	0.832	1.118	-
	Moisture Content	24.8%	44.0%	%
	Saturation	81.8%	100.0%	%
	Change in Moisture Content	-	19.1%	%
	Overburden Mass	-	73.57	g
	Height of Water	2.62	-	cm
	Primary Swell	-	14.6%	%
	Ultimate Swell	-	15.6%	%

NOTES	



Primary Swell (%)	14.6%	
Ultimate Swell (%)	15.6%	
Slope of Primary Swelling	6.11%	% per log cycle
Time to Swell (hr)	10.10	
Slope of Secondary Swelling	1.07%	% per log cycle
Stress (psf)	97	

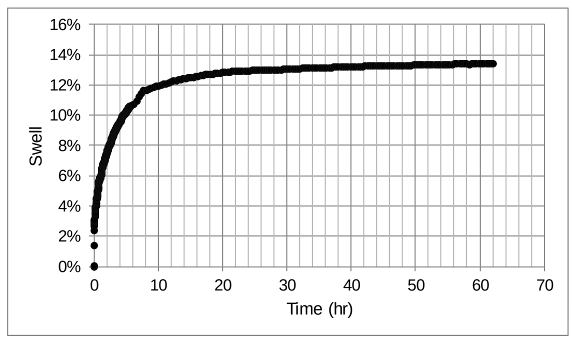
Date test conducted	3/2/2018
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.74	gravity
	Initial Moisture Content	24.0%	24.5%	%
	Mass Soil Added	38.06	38.01	g
	Dry Unit Weight	14.70	14.68	kN/m3
	Height of Sample	1.000	1.011	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.121	cm
	Testing Height	1.007	1.142	cm
	Void Ratio, e	0.831	1.076	-
	Moisture Content	24.5%	43.3%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	18.8%	%
	Overburden Mass	-	74.22	g
	Height of Water	2.61	-	cm
	Primary Swell	-	12.0%	%
	Ultimate Swell	-	13.4%	%

NOTES	



Primary Swell (%)	12.0%	
Ultimate Swell (%)	13.4%	
Slope of Primary Swelling	6.29%	% per log cycle
Time to Swell (hr)	10.88	
Slope of Secondary Swelling	1.64%	% per log cycle
Stress (psf)	98	

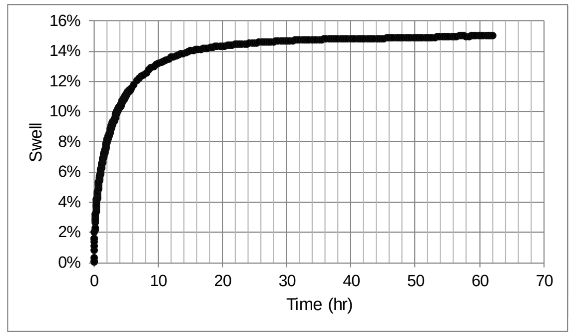
Date test conducted	3/2/2018
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	10.00	10.74	gravity
	Initial Moisture Content	24.0%	26.6%	%
	Mass Soil Added	38.68	38.62	g
	Dry Unit Weight	14.93	14.64	kN/m3
	Height of Sample	1.000	1.011	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.078	cm
	Testing Height	1.008	1.160	cm
	Void Ratio, e	0.836	1.112	-
	Moisture Content	26.6%	43.0%	%
	Saturation	87.2%	100.0%	%
	Change in Moisture Content	-	16.4%	%
	Overburden Mass	-	73.35	g
	Height of Water	2.62	-	cm
	Primary Swell	-	14.4%	%
	Ultimate Swell	-	15.0%	%

NOTES	



Primary Swell (%)	14.4%
Ultimate Swell (%)	15.0%
Slope of Primary Swelling	6.08% % per log cycle
Time to Swell (hr)	21.58
Slope of Secondary Swelling	1.41% % per log cycle
Stress (psf)	97

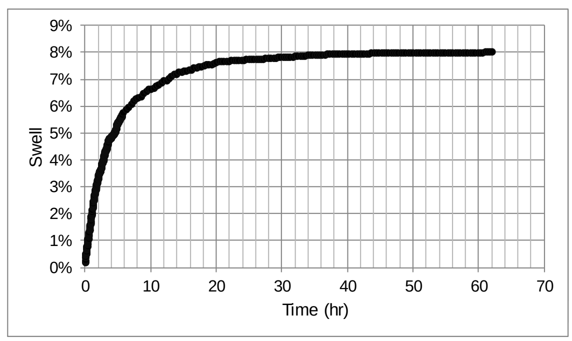
Date test conducted	3/2/2018
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	29%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	10.00	10.74	gravity
	Initial Moisture Content	24.0%	29.1%	%
	Mass Soil Added	39.27	39.20	g
	Dry Unit Weight	15.06	14.52	kN/m3
	Height of Sample	1.000	1.018	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.075	cm
	Testing Height	1.012	1.093	cm
	Void Ratio, e	0.851	0.999	-
	Moisture Content	29.1%	42.9%	%
	Saturation	93.8%	100.0%	%
	Change in Moisture Content	-	13.8%	%
	Overburden Mass	-	74.39	g
	Height of Water	2.63	-	cm
	Primary Swell	-	7.5%	%
	Ultimate Swell	-	8.0%	%

NOTES	



Primary Swell (%)	7.5%
Ultimate Swell (%)	8.0%
Slope of Primary Swelling	4.81% % per log cycle
Time to Swell (hr)	17.41
Slope of Secondary Swelling	0.42% % per log cycle
Stress (psf)	98

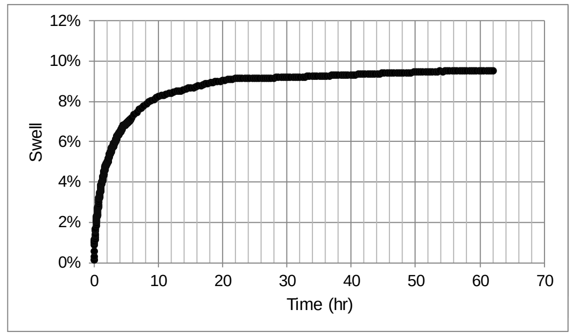
Date test conducted	3/2/2018
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	29%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	10.00	10.74	gravity
	Initial Moisture Content	24.0%	29.2%	%
	Mass Soil Added	39.30	39.24	g
	Dry Unit Weight	14.99	14.41	kN/m3
	Height of Sample	1.000	1.024	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.075	cm
	Testing Height	1.020	1.117	cm
	Void Ratio, e	0.865	1.043	-
	Moisture Content	29.2%	42.2%	%
	Saturation	92.5%	100.0%	%
	Change in Moisture Content	-	13.0%	%
	Overburden Mass	-	75.20	g
	Height of Water	2.62	-	cm
	Primary Swell	-	8.8%	%
	Ultimate Swell	-	9.5%	%

NOTES	



Primary Swell (%)	8.8%
Slope of Primary Swelling	4.48% % per log cycle
Slope of Secondary Swelling	1.01% % per log cycle

Ultimate Swell (%)	9.5%
Time to Swell (hr)	16.63
Stress (psf)	99

Date test conducted	
Centrifuge used	
Cup Number	
Conducted by	

SOIL Information		
	Soil	
	Target Water Content	
	Water Content	
	Specific Gravity	

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level			gravity
	Initial Moisture Content			%
	Mass Soil Added			gravity
	Dry Unit Weight			kN/m3
	Height of Sample			cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height			cm
	Testing Height			cm
	Void Ratio, e			-
	Moisture Content			%
	Saturation			%
	Change in Moisture Content			%
	Overburden Mass			g
	Height of Water			cm
	Primary Swell			%
	Ultimate Swell			%

NOTES	

Primary Swell (%)	
Slope of Primary Swelling	% per log cycle
Slope of Secondary Swelling	% per log cycle

Ultimate Swell (%)	
Time to Swell (hr)	
Stress (psf)	

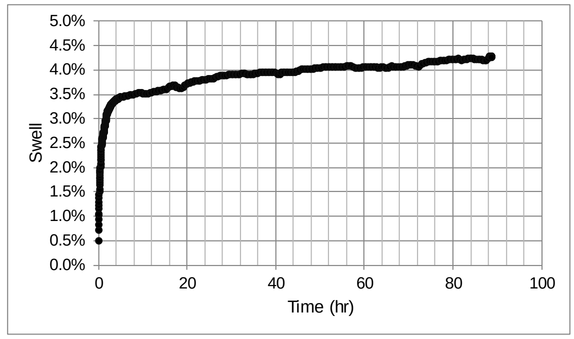
Date test conducted	5/4/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	31.99	gravity
	Initial Moisture Content	24.0%	27.2%	%
	Mass Soil Added	33.35	33.21	g
	Dry Unit Weight	13.05	12.99	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.028	cm
	Testing Height	0.973	1.015	cm
	Void Ratio, e	1.070	1.158	-
	Moisture Content	27.2%	48.4%	%
	Saturation	69.7%	100.0%	%
	Change in Moisture Content	-	21.2%	%
	Overburden Mass	-	72.57	g
	Height of Water	2.81	-	cm
	Primary Swell	-	3.2%	%
	Ultimate Swell	-	4.3%	%

NOTES	



Primary Swell (%)	3.2%		Ultimate Swell (%)	4.3%
Slope of Primary Swelling	1.65%	% per log cycle	Time to Swell (hr)	2.41
Slope of Secondary Swelling	0.60%	% per log cycle	Stress (psf)	280

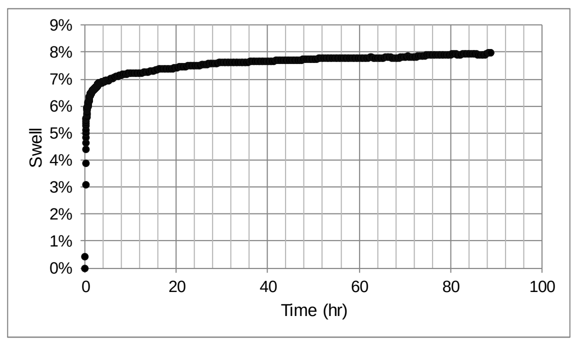
Date test conducted	5/4/2018
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	31.99	gravity
	Initial Moisture Content	24.0%	26.9%	%
	Mass Soil Added	33.35	33.22	g
	Dry Unit Weight	13.09	12.95	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.034	cm
	Testing Height	0.978	1.056	cm
	Void Ratio, e	1.076	1.241	-
	Moisture Content	26.9%	49.4%	%
	Saturation	68.6%	100.0%	%
	Change in Moisture Content	-	22.4%	%
	Overburden Mass	-	73.54	g
	Height of Water	2.81	-	cm
	Primary Swell	-	6.4%	%
	Ultimate Swell	-	8.0%	%

NOTES	



Primary Swell (%)	6.4%		Ultimate Swell (%)	8.0%
Slope of Primary Swelling	1.70%	% per log cycle	Time to Swell (hr)	1.11
Slope of Secondary Swelling	0.79%	% per log cycle	Stress (psf)	284

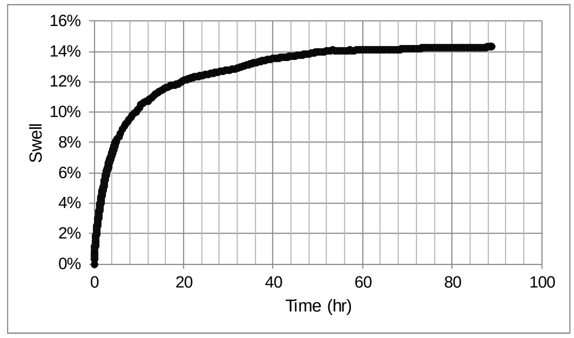
Date test conducted	5/4/2018
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	31.99	gravity
	Initial Moisture Content	24.0%	27.1%	%
	Mass Soil Added	49.60	49.41	g
	Dry Unit Weight	19.35	19.21	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.006	cm
	Testing Height	0.980	1.120	cm
	Void Ratio, e	0.399	0.600	-
	Moisture Content	27.1%	40.7%	%
	Saturation	100.0%	100.0%	%
	Change in Moisture Content	-	13.7%	%
	Overburden Mass	-	73.42	g
	Height of Water	2.82	-	cm
	Primary Swell	-	13.7%	%
	Ultimate Swell	-	14.3%	%

NOTES	



Primary Swell (%)	13.7%		Ultimate Swell (%)	14.3%
Slope of Primary Swelling	6.62%	% per log cycle	Time to Swell (hr)	44.69
Slope of Secondary Swelling	1.52%	% per log cycle	Stress (psf)	297

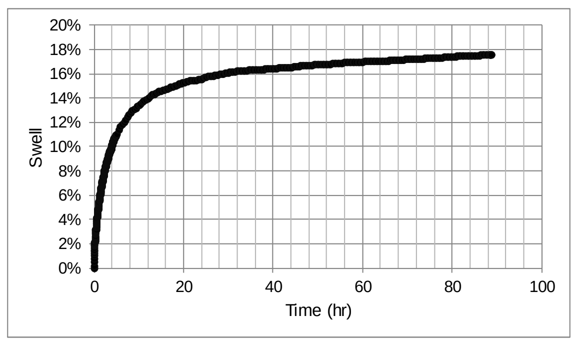
Date test conducted	5/4/2018
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	31.99	gravity
	Initial Moisture Content	24.0%	27.0%	%
	Mass Soil Added	49.60	49.42	g
	Dry Unit Weight	19.38	19.19	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.003	cm
	Testing Height	0.981	1.154	cm
	Void Ratio, e	0.400	0.647	-
	Moisture Content	27.0%	40.8%	%
	Saturation	100.0%	100.0%	%
	Change in Moisture Content	-	13.8%	%
	Overburden Mass	-	73.83	g
	Height of Water	2.80	-	cm
	Primary Swell	-	15.1%	%
	Ultimate Swell	-	17.6%	%

NOTES	



Primary Swell (%)	15.1%		Ultimate Swell (%)	17.6%
Slope of Primary Swelling	8.12%	% per log cycle	Time to Swell (hr)	19.11
Slope of Secondary Swelling	3.36%	% per log cycle	Stress (psf)	298

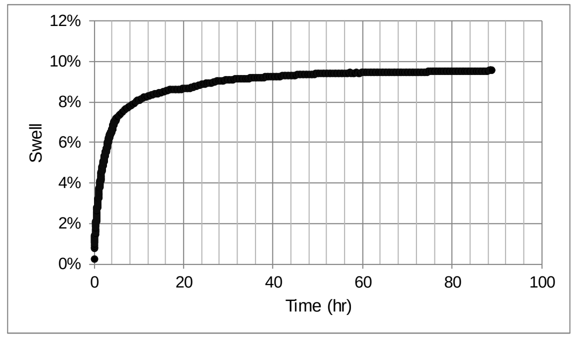
Date test conducted	5/4/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	31.99	gravity
	Initial Moisture Content	24.0%	27.1%	%
	Mass Soil Added	38.11	37.99	g
	Dry Unit Weight	14.92	14.79	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.011	cm
	Testing Height	0.978	1.071	cm
	Void Ratio, e	0.817	0.991	-
	Moisture Content	27.1%	43.5%	%
	Saturation	91.0%	100.0%	%
	Change in Moisture Content	-	16.4%	%
	Overburden Mass	-	73.81	g
	Height of Water	2.81	-	cm
	Primary Swell	-	7.7%	%
	Ultimate Swell	-	9.6%	%

NOTES	



Primary Swell (%)	7.7%	Ultimate Swell (%)	9.6%
Slope of Primary Swelling	5.50% % per log cycle	Time to Swell (hr)	7.46
Slope of Secondary Swelling	1.46% % per log cycle	Stress (psf)	288

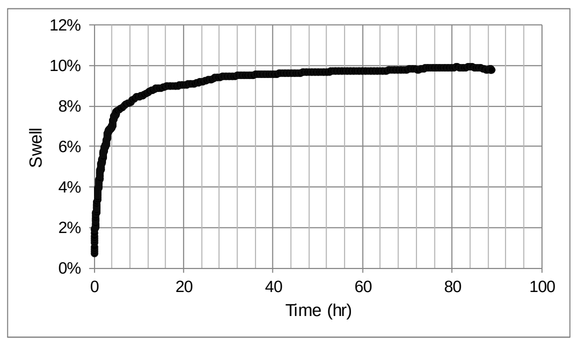
Date test conducted	5/4/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	27%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	31.99	gravity
	Initial Moisture Content	24.0%	27.2%	%
	Mass Soil Added	38.13	38.07	g
	Dry Unit Weight	14.86	14.82	kN/m3
	Height of Sample	1.000	1.002	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.029	cm
	Testing Height	0.978	1.075	cm
	Void Ratio, e	0.814	0.995	-
	Moisture Content	27.2%	41.1%	%
	Saturation	91.4%	100.0%	%
	Change in Moisture Content	-	14.0%	%
	Overburden Mass	-	73.65	g
	Height of Water	2.81	-	cm
	Primary Swell	-	8.1%	%
	Ultimate Swell	-	9.9%	%

NOTES	



Primary Swell (%)	8.1%	Ultimate Swell (%)	9.9%
Slope of Primary Swelling	5.00% % per log cycle	Time to Swell (hr)	7.46
Slope of Secondary Swelling	1.53% % per log cycle	Stress (psf)	288

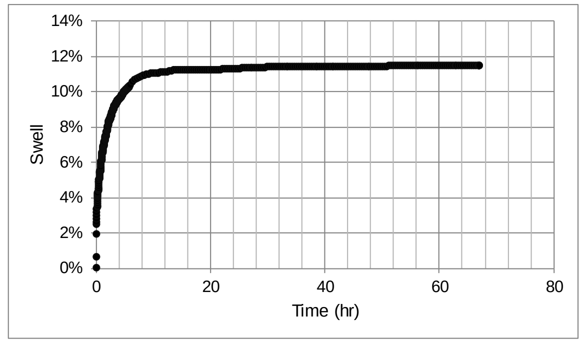
Date test conducted	3/21/2018	
Centrifuge used	2	
Cup Number	1	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	15.00	18.34	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.04	37.99	g
	Dry Unit Weight	14.53	14.62	kN/m3
	Height of Sample	1.000	1.022	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.078	cm
	Testing Height	1.019	1.136	cm
	Void Ratio, e	0.839	1.050	-
	Moisture Content	23.5%	41.5%	%
	Saturation	76.7%	100.0%	%
	Change in Moisture Content	-	18.0%	%
	Overburden Mass	-	73.54	g
	Height of Water	2.24	-	cm
	Primary Swell	-	10.8%	%
	Ultimate Swell	-	11.5%	%

NOTES	
	50 mL water added



Primary Swell (%)	10.8%	Ultimate Swell (%)	11.5%
Slope of Primary Swelling	5.65% % per log cycle	Time to Swell (hr)	7.46
Slope of Secondary Swelling	0.45% % per log cycle	Stress (psf)	166

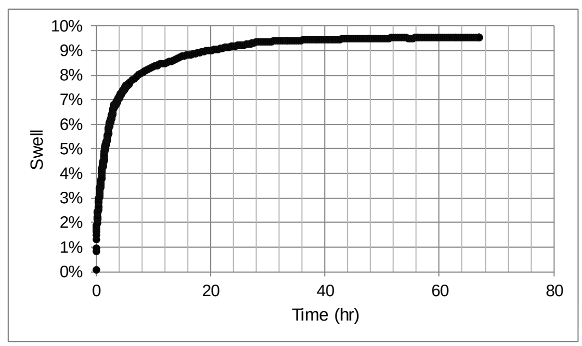
Date test conducted	3/21/2018	
Centrifuge used	2	
Cup Number	2	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	15.00	18.34	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.04	37.97	g
	Dry Unit Weight	14.75	14.85	kN/m3
	Height of Sample	1.000	1.007	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.126	cm
	Testing Height	1.002	1.098	cm
	Void Ratio, e	0.810	0.982	-
	Moisture Content	23.5%	41.5%	%
	Saturation	79.4%	100.0%	%
	Change in Moisture Content	-	18.0%	%
	Overburden Mass	-	73.74	g
	Height of Water	2.25	-	cm
	Primary Swell	-	9.4%	%
	Ultimate Swell	-	9.5%	%

NOTES	
	50 mL water added



Primary Swell (%)	9.4%	Ultimate Swell (%)	9.5%
Slope of Primary Swelling	2.64% % per log cycle	Time to Swell (hr)	28.80
Slope of Secondary Swelling	0.34% % per log cycle	Stress (psf)	166

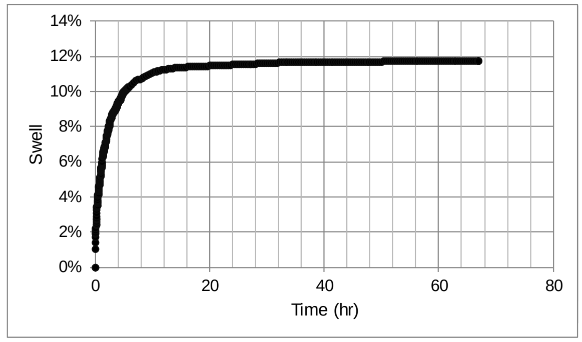
Date test conducted	3/21/2018
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	15.00	18.34	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.01	37.99	g
	Dry Unit Weight	14.56	14.60	kN/m3
	Height of Sample	1.000	1.019	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.047	cm
	Testing Height	1.018	1.137	cm
	Void Ratio, e	0.841	1.057	-
	Moisture Content	23.7%	41.3%	%
	Saturation	77.2%	100.0%	%
	Change in Moisture Content	-	17.6%	%
	Overburden Mass	-	73.93	g
	Height of Water	4.12	-	cm
	Primary Swell	-	10.7%	%
	Ultimate Swell	-	11.7%	%

NOTES	
	100 mL water added



Primary Swell (%)	10.7%		Ultimate Swell (%)	11.7%
Slope of Primary Swelling	6.62%	% per log cycle	Time to Swell (hr)	7.80
Slope of Secondary Swelling	0.56%	% per log cycle	Stress (psf)	167

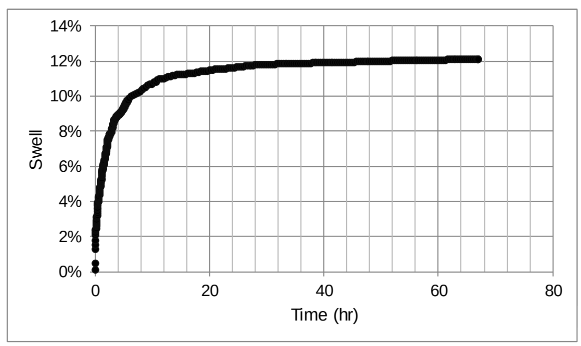
Date test conducted	3/21/2018
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	15.00	18.34	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	35.98	35.93	g
	Dry Unit Weight	14.70	14.81	kN/m3
	Height of Sample	1.000	0.956	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.106	cm
	Testing Height	0.951	1.067	cm
	Void Ratio, e	0.815	1.035	-
	Moisture Content	23.4%	41.3%	%
	Saturation	78.8%	100.0%	%
	Change in Moisture Content	-	17.9%	%
	Overburden Mass	-	73.49	g
	Height of Water	4.13	-	cm
	Primary Swell	-	11.6%	%
	Ultimate Swell	-	12.1%	%

NOTES	
	100 mL water added



Primary Swell (%)	11.6%		Ultimate Swell (%)	12.1%
Slope of Primary Swelling	4.19%	% per log cycle	Time to Swell (hr)	22.16
Slope of Secondary Swelling	0.95%	% per log cycle	Stress (psf)	164

0

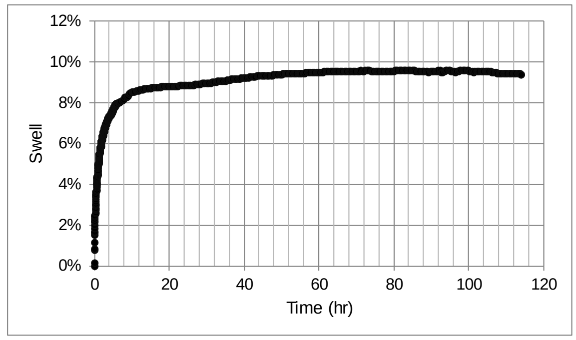
Date test conducted	4/5/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	25.83	gravity
	Initial Moisture Content	24.0%	23.2%	%
	Mass Soil Added	38.01	37.94	g
	Dry Unit Weight	14.60	14.89	kN/m3
	Height of Sample	1.000	1.017	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.015	cm
	Testing Height	1.001	1.097	cm
	Void Ratio, e	0.805	0.978	-
	Moisture Content	23.2%	39.1%	%
	Saturation	79.0%	100.0%	%
	Change in Moisture Content	-	15.9%	%
	Overburden Mass	-	73.89	g
	Height of Water	2.62	-	cm
	Primary Swell	-	9.6%	%
	Ultimate Swell	-	9.6%	%

NOTES	No vacuum grease used



Primary Swell (%)	9.6%	
Slope of Primary Swelling	1.42%	% per log cycle
Slope of Secondary Swelling	-0.01%	% per log cycle

Ultimate Swell (%)	9.6%
Time to Swell (hr)	69.44
Stress (psf)	235

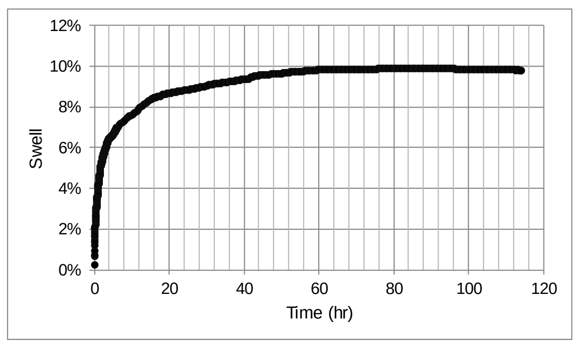
Date test conducted	4/5/2018
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	25.83	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.00	37.95	g
	Dry Unit Weight	14.64	14.94	kN/m3
	Height of Sample	1.000	1.013	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.019	cm
	Testing Height	0.996	1.095	cm
	Void Ratio, e	0.799	0.978	-
	Moisture Content	23.5%	39.2%	%
	Saturation	80.4%	100.0%	%
	Change in Moisture Content	-	15.8%	%
	Overburden Mass	-	73.76	g
	Height of Water	2.62	-	cm
	Primary Swell	-	9.8%	%
	Ultimate Swell	-	9.9%	%

NOTES	No vacuum grease used



Primary Swell (%)	9.8%	
Slope of Primary Swelling	3.33%	% per log cycle
Slope of Secondary Swelling	-0.36%	% per log cycle

Ultimate Swell (%)	9.9%
Time to Swell (hr)	58.90
Stress (psf)	234

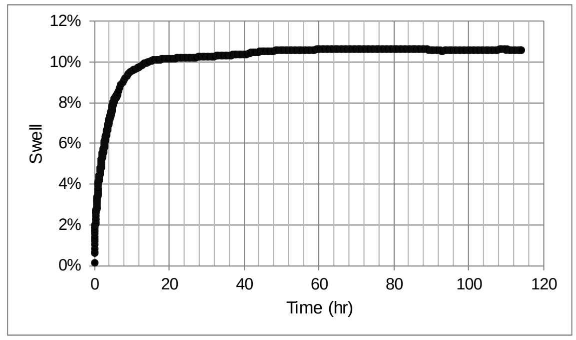
Date test conducted	4/5/2018
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	25.83	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.01	37.97	g
	Dry Unit Weight	14.60	14.87	kN/m3
	Height of Sample	1.000	1.017	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.033	cm
	Testing Height	0.999	1.106	cm
	Void Ratio, e	0.807	1.000	-
	Moisture Content	23.6%	38.7%	%
	Saturation	80.2%	100.0%	%
	Change in Moisture Content	-	15.0%	%
	Overburden Mass	-	75.33	g
	Height of Water	2.61	-	cm
	Primary Swell	-	9.9%	%
	Ultimate Swell	-	10.6%	%

NOTES	
	0.05 g vacuum grease



Primary Swell (%)	9.9%	
Ultimate Swell (%)	10.6%	
Slope of Primary Swelling	5.67%	% per log cycle
Time to Swell (hr)	13.09	
Slope of Secondary Swelling	0.57%	% per log cycle
Stress (psf)	238	

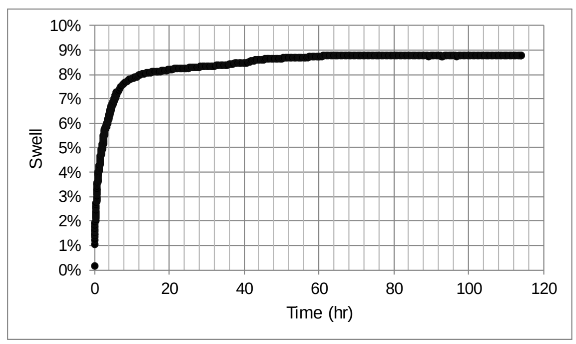
Date test conducted	4/5/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	25.83	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.03	37.99	g
	Dry Unit Weight	14.57	14.81	kN/m3
	Height of Sample	1.000	1.019	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.026	cm
	Testing Height	1.004	1.092	cm
	Void Ratio, e	0.815	0.974	-
	Moisture Content	23.6%	41.5%	%
	Saturation	79.5%	100.0%	%
	Change in Moisture Content	-	17.8%	%
	Overburden Mass	-	73.59	g
	Height of Water	2.62	-	cm
	Primary Swell	-	7.8%	%
	Ultimate Swell	-	8.8%	%

NOTES	
	0.1 g vacuum grease



Primary Swell (%)	7.8%	
Ultimate Swell (%)	8.8%	
Slope of Primary Swelling	4.21%	% per log cycle
Time to Swell (hr)	9.75	
Slope of Secondary Swelling	0.75%	% per log cycle
Stress (psf)	233	

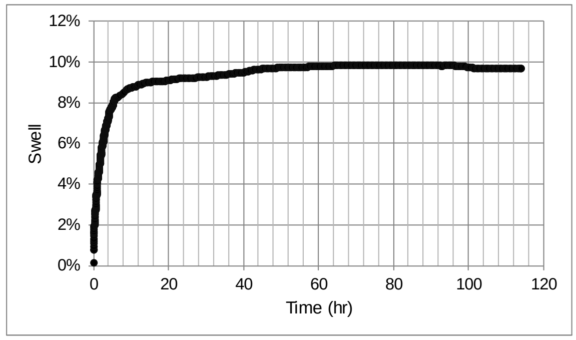
Date test conducted	4/5/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	25.83	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.02	37.98	g
	Dry Unit Weight	14.52	14.75	kN/m3
	Height of Sample	1.000	1.022	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.012	cm
	Testing Height	1.009	1.108	cm
	Void Ratio, e	0.823	1.002	-
	Moisture Content	23.6%	39.4%	%
	Saturation	78.6%	100.0%	%
	Change in Moisture Content	-	15.8%	%
	Overburden Mass	-	74.34	g
	Height of Water	2.62	-	cm
	Primary Swell	-	8.4%	%
	Ultimate Swell	-	9.8%	%

NOTES	
	0.1 g vacuum grease



Primary Swell (%)	8.4%	
Slope of Primary Swelling	5.63%	% per log cycle
Slope of Secondary Swelling	0.75%	% per log cycle

Ultimate Swell (%)	9.8%
Time to Swell (hr)	7.50
Stress (psf)	235

Date test conducted	
Centrifuge used	
Cup Number	
Conducted by	

SOIL Information		
	Soil	
	Target Water Content	
	Water Content	
	Specific Gravity	

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level			gravity
	Initial Moisture Content			%
	Mass Soil Added			g
	Dry Unit Weight			kN/m3
	Height of Sample			cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height			cm
	Testing Height			cm
	Void Ratio, e			-
	Moisture Content			%
	Saturation			%
	Change in Moisture Content			%
	Overburden Mass			g
	Height of Water			cm
	Primary Swell			%
	Ultimate Swell			%

NOTES	

Primary Swell (%)		
Slope of Primary Swelling		% per log cycle
Slope of Secondary Swelling		% per log cycle

Ultimate Swell (%)	
Time to Swell (hr)	
Stress (psf)	

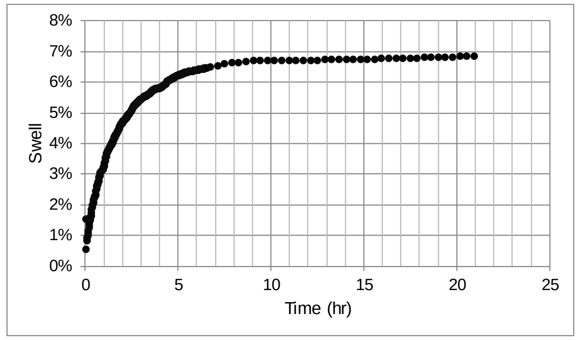
Date test conducted	9/27/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30+	33.68	gravity
	Initial Moisture Content	24.0%	24.7%	%
	Mass Soil Added	38.02	37.92	g
	Dry Unit Weight	14.81	14.76	kN/m3
	Height of Sample	1.000	1.002	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.150	cm
	Testing Height	0.997	1.065	cm
	Void Ratio, e	0.821	0.945	-
	Moisture Content	24.7%	35.3%	%
	Saturation	82.5%	100.0%	%
	Change in Moisture Content	-	10.6%	%
	Overburden Mass	-	74.54	g
	Height of Water	2.27	-	cm
	Primary Swell	-	6.4%	%
	Ultimate Swell	-	6.8%	%

NOTES	



Primary Swell (%)	6.4%		Ultimate Swell (%)	6.8%
Slope of Primary Swelling	4.03%	% per log cycle	Time to Swell (hr)	6.21
Slope of Secondary Swelling	0.43%	% per log cycle	Stress (psf)	307

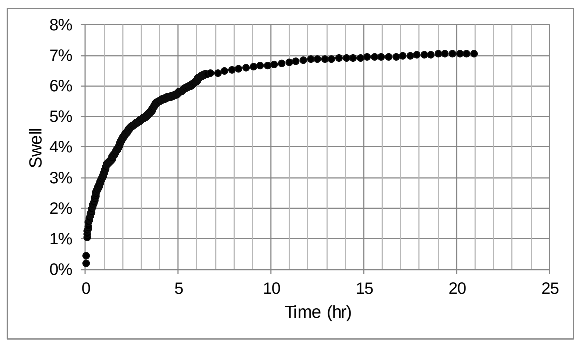
Date test conducted	9/27/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30+	33.68	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	38.02	37.98	g
	Dry Unit Weight	14.83	14.81	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.118	cm
	Testing Height	0.996	1.067	cm
	Void Ratio, e	0.815	0.943	-
	Moisture Content	24.6%	32.3%	%
	Saturation	82.7%	93.8%	%
	Change in Moisture Content	-	7.7%	%
	Overburden Mass	-	73.66	g
	Height of Water	2.28	-	cm
	Primary Swell	-	6.6%	%
	Ultimate Swell	-	7.0%	%

NOTES	



Primary Swell (%)	6.6%		Ultimate Swell (%)	7.0%
Slope of Primary Swelling	3.54%	% per log cycle	Time to Swell (hr)	8.27
Slope of Secondary Swelling	1.14%	% per log cycle	Stress (psf)	304

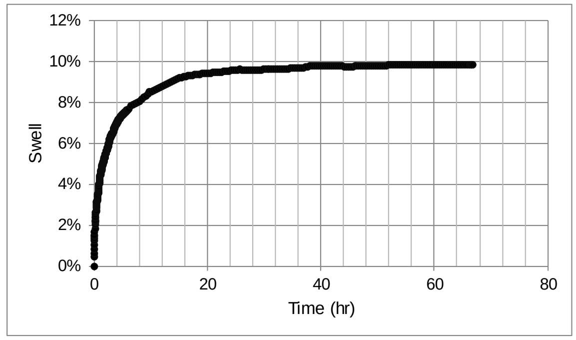
Date test conducted	3/24/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.49	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	38.05	37.98	g
	Dry Unit Weight	14.65	14.87	kN/m3
	Height of Sample	1.000	1.013	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.062	cm
	Testing Height	0.998	1.096	cm
	Void Ratio, e	0.808	0.986	-
	Moisture Content	23.9%	41.1%	%
	Saturation	81.0%	100.0%	%
	Change in Moisture Content	-	17.3%	%
	Overburden Mass	-	73.53	g
	Height of Water	2.62	-	cm
	Primary Swell	-	8.9%	%
	Ultimate Swell	-	9.9%	%

NOTES	oven-dried



Primary Swell (%)	8.9%		Ultimate Swell (%)	9.9%
Slope of Primary Swelling	4.59%	% per log cycle	Time to Swell (hr)	13.17
Slope of Secondary Swelling	0.85%	% per log cycle	Stress (psf)	203

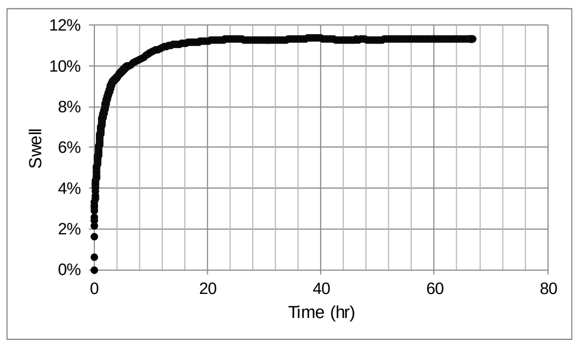
Date test conducted	3/24/2018
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.49	gravity
	Initial Moisture Content	24.0%	24.5%	%
	Mass Soil Added	38.08	38.04	g
	Dry Unit Weight	14.62	14.71	kN/m3
	Height of Sample	1.000	1.017	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.043	cm
	Testing Height	1.005	1.119	cm
	Void Ratio, e	0.827	1.034	-
	Moisture Content	24.5%	42.8%	%
	Saturation	81.3%	100.0%	%
	Change in Moisture Content	-	18.3%	%
	Overburden Mass	-	75.24	g
	Height of Water	2.62	-	cm
	Primary Swell	-	11.1%	%
	Ultimate Swell	-	11.4%	%

NOTES	air-dried



Primary Swell (%)	11.1%		Ultimate Swell (%)	11.4%
Slope of Primary Swelling	3.15%	% per log cycle	Time to Swell (hr)	15.04
Slope of Secondary Swelling	0.21%	% per log cycle	Stress (psf)	207

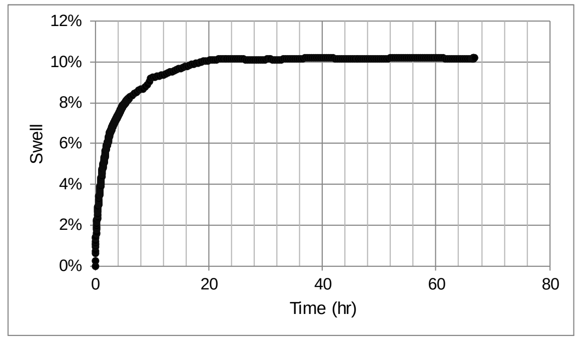
Date test conducted	3/24/2018
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.49	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.08	37.94	g
	Dry Unit Weight	14.58	14.73	kN/m3
	Height of Sample	1.000	1.020	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.027	cm
	Testing Height	1.008	1.111	cm
	Void Ratio, e	0.824	1.011	-
	Moisture Content	23.6%	41.4%	%
	Saturation	78.5%	100.0%	%
	Change in Moisture Content	-	17.8%	%
	Overburden Mass	-	74.24	g
	Height of Water	2.62	-	cm
	Primary Swell	-	9.8%	%
	Ultimate Swell	-	10.2%	%

NOTES	oven-dried



Primary Swell (%)	9.8%	
Slope of Primary Swelling	4.97%	% per log cycle
Slope of Secondary Swelling	0.24%	% per log cycle

Ultimate Swell (%)	10.2%
Time to Swell (hr)	15.80
Stress (psf)	205

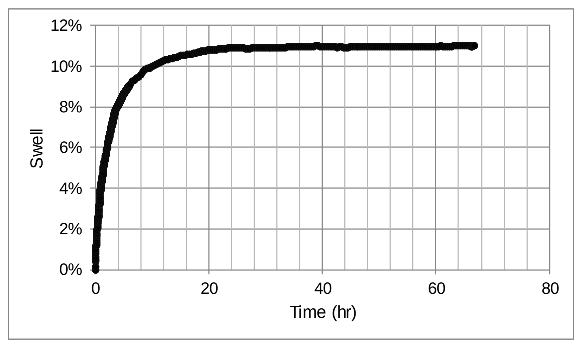
Date test conducted	3/24/2018
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.49	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	38.05	37.99	g
	Dry Unit Weight	14.65	14.67	kN/m3
	Height of Sample	1.000	1.013	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.029	cm
	Testing Height	1.006	1.116	cm
	Void Ratio, e	0.832	1.034	-
	Moisture Content	24.6%	42.7%	%
	Saturation	81.1%	100.0%	%
	Change in Moisture Content	-	18.0%	%
	Overburden Mass	-	73.82	g
	Height of Water	2.62	-	cm
	Primary Swell	-	10.8%	%
	Ultimate Swell	-	11.0%	%

NOTES	air-dried



Primary Swell (%)	10.8%	
Slope of Primary Swelling	4.38%	% per log cycle
Slope of Secondary Swelling	0.27%	% per log cycle

Ultimate Swell (%)	11.0%
Time to Swell (hr)	21.35
Stress (psf)	204

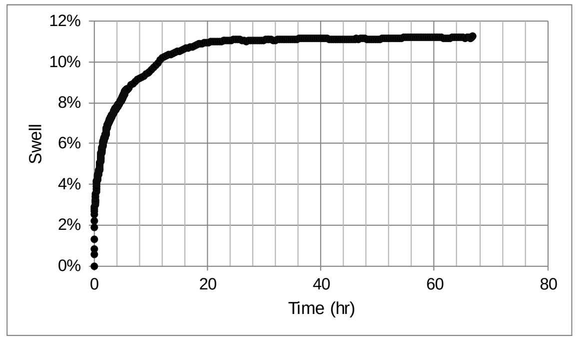
Date test conducted	3/24/2018	
Centrifuge used	3	
Cup Number	5	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	22.49	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	38.05	37.93	g
	Dry Unit Weight	14.60	14.90	kN/m3
	Height of Sample	1.000	1.018	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.042	cm
	Testing Height	0.998	1.111	cm
	Void Ratio, e	0.804	1.007	-
	Moisture Content	23.4%	42.1%	%
	Saturation	79.7%	100.0%	%
	Change in Moisture Content	-	18.7%	%
	Overburden Mass	-	73.47	g
	Height of Water	2.62	-	cm
	Primary Swell	-	11.0%	%
	Ultimate Swell	-	11.3%	%

NOTES	oven-dried



Primary Swell (%)	11.0%		Ultimate Swell (%)	11.3%
Slope of Primary Swelling	4.40%	% per log cycle	Time to Swell (hr)	22.08
Slope of Secondary Swelling	0.43%	% per log cycle	Stress (psf)	203

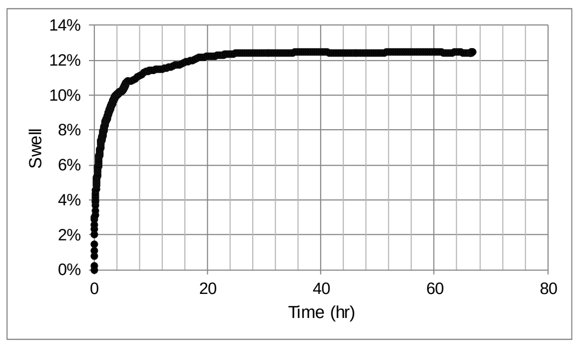
Date test conducted	3/24/2018	
Centrifuge used	3	
Cup Number	6	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	22.49	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	38.07	38.04	g
	Dry Unit Weight	14.66	14.70	kN/m3
	Height of Sample	1.000	1.013	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.040	cm
	Testing Height	1.003	1.129	cm
	Void Ratio, e	0.829	1.057	-
	Moisture Content	24.8%	42.5%	%
	Saturation	82.1%	100.0%	%
	Change in Moisture Content	-	17.7%	%
	Overburden Mass	-	73.64	g
	Height of Water	2.62	-	cm
	Primary Swell	-	12.3%	%
	Ultimate Swell	-	12.5%	%

NOTES	air-dried



Primary Swell (%)	12.3%		Ultimate Swell (%)	12.5%
Slope of Primary Swelling	4.36%	% per log cycle	Time to Swell (hr)	22.79
Slope of Secondary Swelling	0.13%	% per log cycle	Stress (psf)	204

APPENDIX B: LIME-TREATED EAGLE FORD CLAY CENTRIFUGE TEST RESULTS

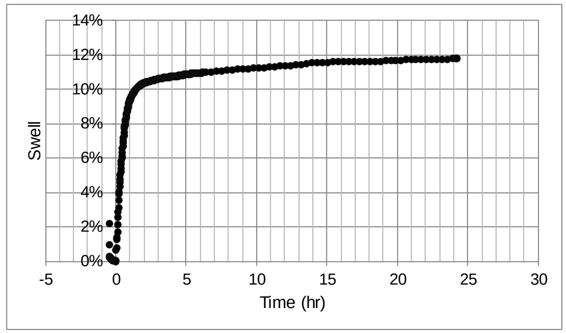
Date test conducted	6/14/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	28.29	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.91	37.78	g
	Dry Unit Weight	14.72	14.62	kN/m3
	Height of Sample	1.000	1.005	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.197	cm
	Testing Height	1.003	1.121	cm
	Void Ratio, e	0.838	1.055	-
	Moisture Content	24.6%	42.3%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	17.6%	%
	Overburden Mass	-	40.00	g
	Height of Water	2.30	-	cm
	Primary Swell	-	9.6%	%
	Ultimate Swell	-	11.8%	%

NOTES	1% HL



Primary Swell (%)	9.6%	Ultimate Swell (%)	11.8%
Slope of Primary Swelling	8.82% % per log cycle	Time to Swell (hr)	1.11
Slope of Secondary Swelling	1.37% % per log cycle	Stress (psf)	163

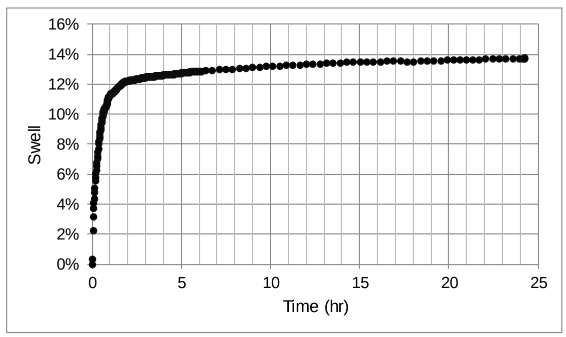
Date test conducted	6/14/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	28.29	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.92	37.80	g
	Dry Unit Weight	14.74	14.63	kN/m3
	Height of Sample	1.000	1.004	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.891	cm
	Testing Height	1.004	1.141	cm
	Void Ratio, e	0.838	1.090	-
	Moisture Content	24.6%	43.7%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	19.1%	%
	Overburden Mass	-	40.25	g
	Height of Water	2.30	-	cm
	Primary Swell	-	11.4%	%
	Ultimate Swell	-	13.7%	%

NOTES	1% HL



Primary Swell (%)	11.4%	Ultimate Swell (%)	13.7%
Slope of Primary Swelling	8.28% % per log cycle	Time to Swell (hr)	1.13
Slope of Secondary Swelling	1.45% % per log cycle	Stress (psf)	164

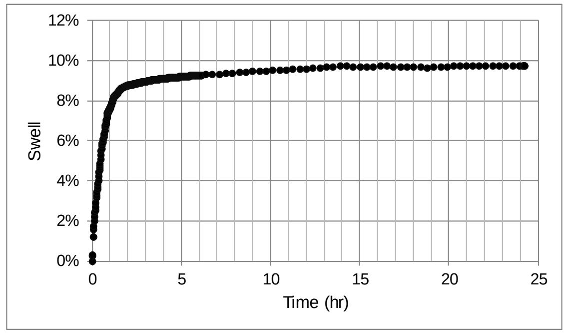
Date test conducted	6/14/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	30.00	28.29	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.91	37.83	g
	Dry Unit Weight	14.72	14.64	kN/m3
	Height of Sample	1.000	1.005	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	-0.081	cm
	Testing Height	1.004	1.102	cm
	Void Ratio, e	0.836	1.016	-
	Moisture Content	24.6%	39.7%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	15.2%	%
	Overburden Mass	-	73.72	g
	Height of Water	2.28	-	cm
	Primary Swell	-	8.3%	%
	Ultimate Swell	-	9.8%	%

NOTES	1% HL



Primary Swell (%)	**8.3%**	
Slope of Primary Swelling	7.38%	% per log cycle
Slope of Secondary Swelling	0.87%	% per log cycle

Ultimate Swell (%)	**9.8%**
Time to Swell (hr)	**1.39**
Stress (psf)	**256**

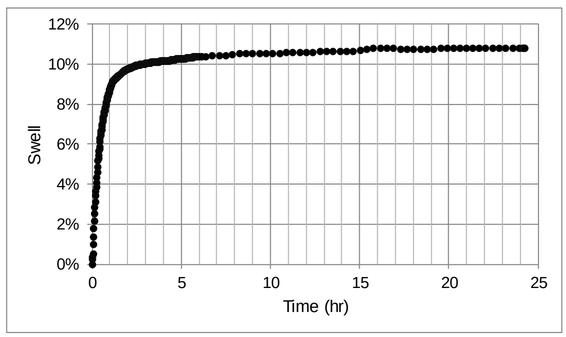
Date test conducted	6/14/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	30.00	28.29	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	37.90	37.82	g
	Dry Unit Weight	14.84	14.70	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	-0.041	cm
	Testing Height	0.996	1.104	cm
	Void Ratio, e	0.828	1.026	-
	Moisture Content	25.0%	41.4%	%
	Saturation	82.8%	100.0%	%
	Change in Moisture Content	-	16.4%	%
	Overburden Mass	-	74.17	g
	Height of Water	2.31	-	cm
	Primary Swell	-	9.3%	%
	Ultimate Swell	-	10.8%	%

NOTES	1% HL



Primary Swell (%)	**9.3%**	
Slope of Primary Swelling	8.04%	% per log cycle
Slope of Secondary Swelling	0.91%	% per log cycle

Ultimate Swell (%)	**10.8%**
Time to Swell (hr)	**1.28**
Stress (psf)	**257**

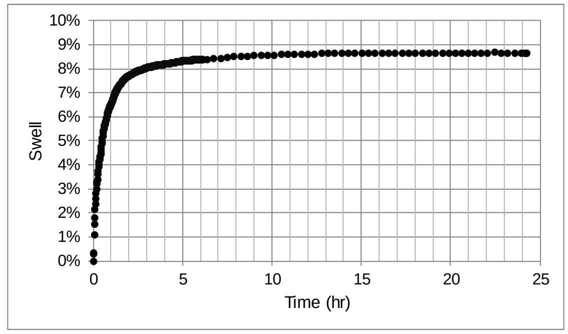
Date test conducted	6/14/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	28.29	gravity
	Initial Moisture Content	24.0%	25.2%	%
	Mass Soil Added	37.90	37.86	g
	Dry Unit Weight	14.82	14.68	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.076	cm
	Testing Height	0.997	1.084	cm
	Void Ratio, e	0.831	0.990	-
	Moisture Content	25.2%	40.1%	%
	Saturation	83.0%	100.0%	%
	Change in Moisture Content	-	14.9%	%
	Overburden Mass	-	141.21	g
	Height of Water	2.29	-	cm
	Primary Swell	-	7.6%	%
	Ultimate Swell	-	8.7%	%

NOTES	1% HL



Primary Swell (%)	7.6%	Ultimate Swell (%)	8.7%
Slope of Primary Swelling	5.14% % per log cycle	Time to Swell (hr)	1.84
Slope of Secondary Swelling	0.64% % per log cycle	Stress (psf)	440

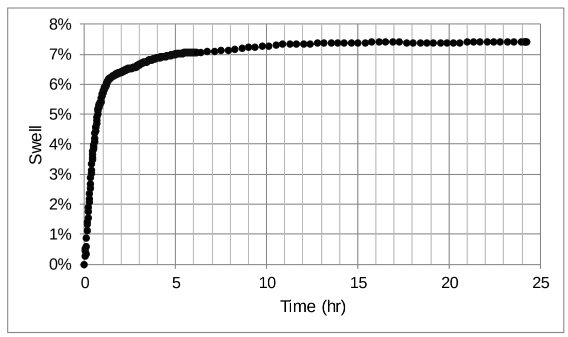
Date test conducted	6/14/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	28.29	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	37.92	37.84	g
	Dry Unit Weight	14.84	14.73	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.122	cm
	Testing Height	0.996	1.070	cm
	Void Ratio, e	0.825	0.960	-
	Moisture Content	24.8%	39.1%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	14.3%	%
	Overburden Mass	-	142.55	g
	Height of Water	2.31	-	cm
	Primary Swell	-	6.1%	%
	Ultimate Swell	-	7.4%	%

NOTES	1% HL



Primary Swell (%)	6.1%	Ultimate Swell (%)	7.4%
Slope of Primary Swelling	6.20% % per log cycle	Time to Swell (hr)	1.28
Slope of Secondary Swelling	0.71% % per log cycle	Stress (psf)	443

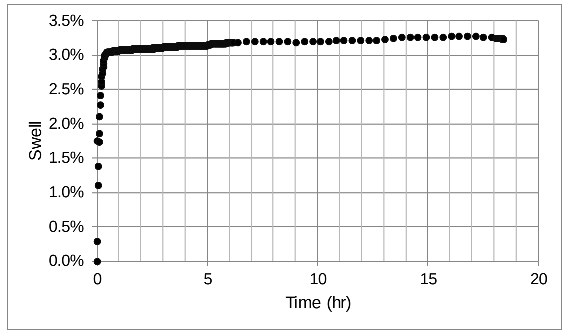
Date test conducted	4/13/2018	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	35.00	34.99	gravity
	Initial Moisture Content	24.0%	24.3%	%
	Mass Soil Added	38.04	37.94	g
	Dry Unit Weight	14.81	14.86	kN/m3
	Height of Sample	1.000	1.002	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	-0.014	cm
	Testing Height	0.995	1.027	cm
	Void Ratio, e	0.809	0.868	-
	Moisture Content	24.3%	35.9%	%
	Saturation	82.2%	100.0%	%
	Change in Moisture Content	-	11.6%	%
	Overburden Mass	-	72.45	g
	Height of Water	2.62	-	cm
	Primary Swell	-	3.0%	%
	Ultimate Swell	-	3.3%	%

NOTES	1% HL



Primary Swell (%)	**3.0%**	**Ultimate Swell (%)**	**3.3%**
Slope of Primary Swelling	2.44% % per log cycle	**Time to Swell (hr)**	**0.34**
Slope of Secondary Swelling	0.17% % per log cycle	**Stress (psf)**	**311**

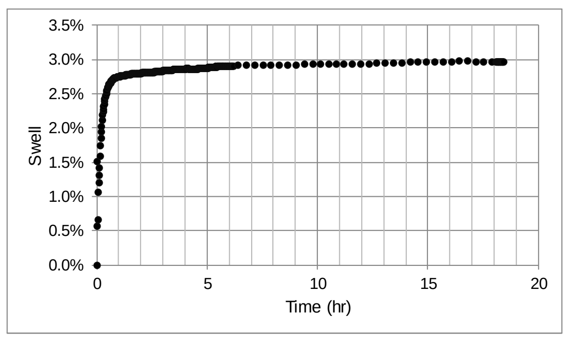
Date test conducted	4/13/2018	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	35.00	34.99	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	38.03	37.93	g
	Dry Unit Weight	14.93	15.17	kN/m3
	Height of Sample	1.000	0.994	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	-0.042	cm
	Testing Height	0.973	1.002	cm
	Void Ratio, e	0.772	0.824	-
	Moisture Content	24.4%	36.7%	%
	Saturation	86.5%	100.0%	%
	Change in Moisture Content	-	12.3%	%
	Overburden Mass	-	75.62	g
	Height of Water	2.63	-	cm
	Primary Swell	-	2.6%	%
	Ultimate Swell	-	3.0%	%

NOTES	1% HL



Primary Swell (%)	**2.6%**	**Ultimate Swell (%)**	**3.0%**
Slope of Primary Swelling	1.99% % per log cycle	**Time to Swell (hr)**	**0.51**
Slope of Secondary Swelling	0.21% % per log cycle	**Stress (psf)**	**321**

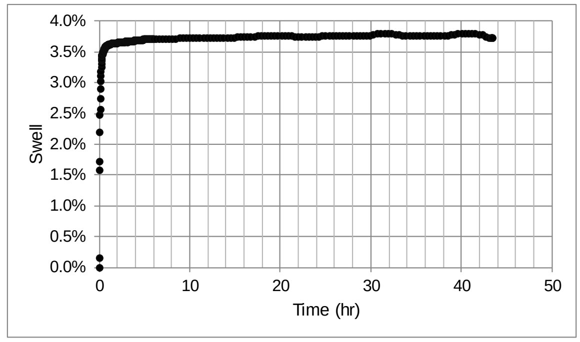
Date test conducted	4/14/2018	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	36.56	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.03	37.96	g
	Dry Unit Weight	14.97	15.13	kN/m3
	Height of Sample	1.000	0.992	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.016	cm
	Testing Height	0.983	1.020	cm
	Void Ratio, e	0.776	0.844	-
	Moisture Content	23.6%	34.3%	%
	Saturation	83.2%	100.0%	%
	Change in Moisture Content	-	10.7%	%
	Overburden Mass	-	75.63	g
	Height of Water	2.63	-	cm
	Primary Swell	-	3.4%	%
	Ultimate Swell	-	3.8%	%

NOTES	1.5% HL



Primary Swell (%)	3.4%		Ultimate Swell (%)	3.8%
Slope of Primary Swelling	2.27%	% per log cycle	Time to Swell (hr)	0.30
Slope of Secondary Swelling	0.11%	% per log cycle	Stress (psf)	336

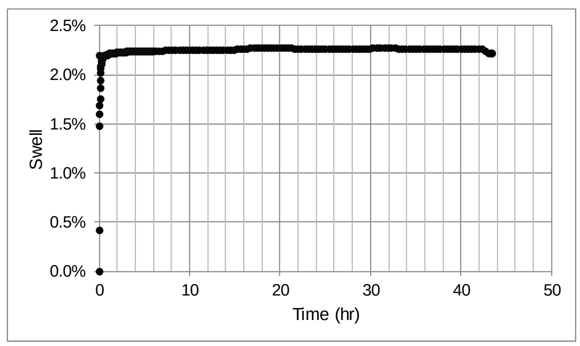
Date test conducted	4/14/2018	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	36.56	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.03	37.89	g
	Dry Unit Weight	14.84	15.05	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.024	cm
	Testing Height	0.987	1.009	cm
	Void Ratio, e	0.785	0.826	-
	Moisture Content	23.5%	34.8%	%
	Saturation	81.8%	100.0%	%
	Change in Moisture Content	-	11.4%	%
	Overburden Mass	-	73.46	g
	Height of Water	2.62	-	cm
	Primary Swell	-	2.1%	%
	Ultimate Swell	-	2.3%	%

NOTES	1.5% HL



Primary Swell (%)	2.1%		Ultimate Swell (%)	2.3%
Slope of Primary Swelling	1.12%	% per log cycle	Time to Swell (hr)	0.26
Slope of Secondary Swelling	0.05%	% per log cycle	Stress (psf)	329

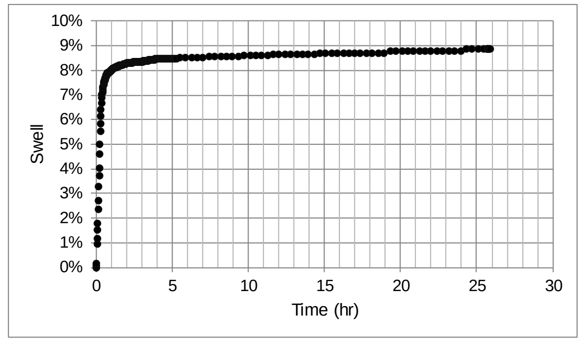
Date test conducted	6/14/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	7.50	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	0.00	37.73	g
	Dry Unit Weight	0.00	14.73	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.067	cm
	Testing Height	0.997	1.085	cm
	Void Ratio, e	0.825	0.987	-
	Moisture Content	24.4%	38.8%	%
	Saturation	81.1%	100.0%	%
	Change in Moisture Content	-	14.4%	%
	Overburden Mass	-	40.31	g
	Height of Water	2.28	-	cm
	Primary Swell	-	7.4%	%
	Ultimate Swell	-	8.9%	%

NOTES	2% HL



Primary Swell (%)	7.4%		Ultimate Swell (%)	8.9%
Slope of Primary Swelling	10.08%	% per log cycle	Time to Swell (hr)	0.50
Slope of Secondary Swelling	0.53%	% per log cycle	Stress (psf)	43

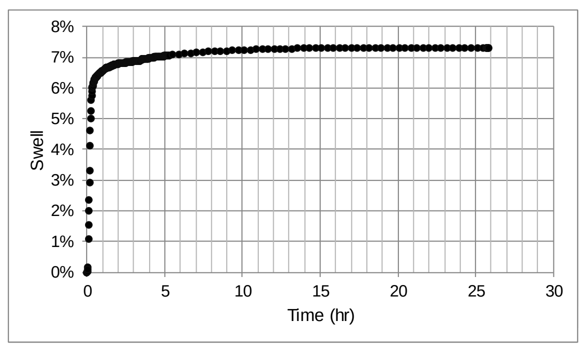
Date test conducted	6/14/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	7.50	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	0.00	37.74	g
	Dry Unit Weight	0.00	14.74	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.228	cm
	Testing Height	1.000	1.073	cm
	Void Ratio, e	0.824	0.957	-
	Moisture Content	24.0%	37.6%	%
	Saturation	79.8%	100.0%	%
	Change in Moisture Content	-	13.6%	%
	Overburden Mass	-	39.92	g
	Height of Water	2.28	-	cm
	Primary Swell	-	6.1%	%
	Ultimate Swell	-	7.3%	%

NOTES	2% HL



Primary Swell (%)	6.1%		Ultimate Swell (%)	7.3%
Slope of Primary Swelling	9.10%	% per log cycle	Time to Swell (hr)	0.37
Slope of Secondary Swelling	0.53%	% per log cycle	Stress (psf)	43

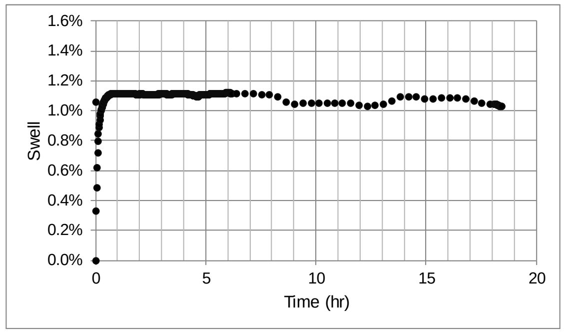
Date test conducted	4/13/2018
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	34.99	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	38.04	37.93	g
	Dry Unit Weight	14.81	14.95	kN/m3
	Height of Sample	1.000	1.003	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.014	cm
	Testing Height	0.990	1.001	cm
	Void Ratio, e	0.798	0.819	-
	Moisture Content	24.1%	34.8%	%
	Saturation	82.8%	100.0%	%
	Change in Moisture Content	-	10.7%	%
	Overburden Mass	-	73.65	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.1%	%
	Ultimate Swell	-	1.1%	%

NOTES	2% HL



Primary Swell (%)	1.1%	Ultimate Swell (%)	1.1%
Slope of Primary Swelling	0.36% % per log cycle	Time to Swell (hr)	0.55
Slope of Secondary Swelling	0.01% % per log cycle	Stress (psf)	315

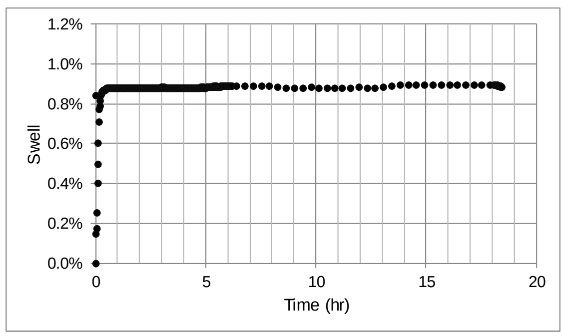
Date test conducted	4/13/2018
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	34.99	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	38.07	37.93	g
	Dry Unit Weight	14.87	14.96	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.014	cm
	Testing Height	0.991	1.000	cm
	Void Ratio, e	0.796	0.812	-
	Moisture Content	23.8%	34.7%	%
	Saturation	82.0%	100.0%	%
	Change in Moisture Content	-	10.8%	%
	Overburden Mass	-	73.38	g
	Height of Water	2.64	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.9%	%

NOTES	2% HL



Primary Swell (%)	0.8%	Ultimate Swell (%)	0.9%
Slope of Primary Swelling	1.27% % per log cycle	Time to Swell (hr)	0.24
Slope of Secondary Swelling	0.01% % per log cycle	Stress (psf)	314

Date test conducted	6/14/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information

Soil	EF
Target Water Content	24%
Water Content	24%
Specific Gravity	2.74

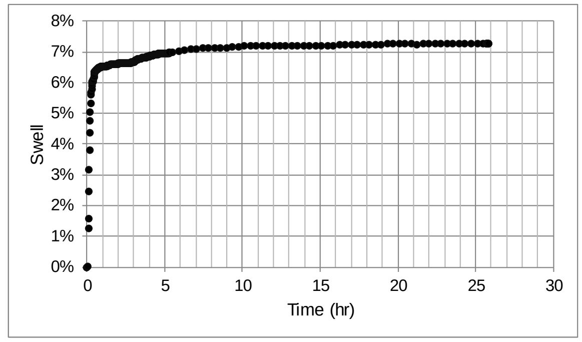
TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	6.00	7.50	gravity
Initial Moisture Content	24.0%	24.5%	%
Mass Soil Added	0.00	37.82	g
Dry Unit Weight	0.00	14.66	kN/m3
Height of Sample	1.000	1.003	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	0.035	cm
Testing Height	1.003	1.076	cm
Void Ratio, e	0.833	0.967	-
Moisture Content	24.5%	37.5%	%
Saturation	80.5%	100.0%	%
Change in Moisture Content	-	13.0%	%
Overburden Mass	-	73.45	g
Height of Water	2.29	-	cm
Primary Swell	-	6.0%	%
Ultimate Swell	-	7.3%	%

NOTES	2% HL



Primary Swell (%)	6.0%		Ultimate Swell (%)	7.3%
Slope of Primary Swelling	8.07%	% per log cycle	Time to Swell (hr)	0.35
Slope of Secondary Swelling	0.65%	% per log cycle	Stress (psf)	67

Date test conducted	6/14/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information

Soil	EF
Target Water Content	24%
Water Content	24%
Specific Gravity	2.74

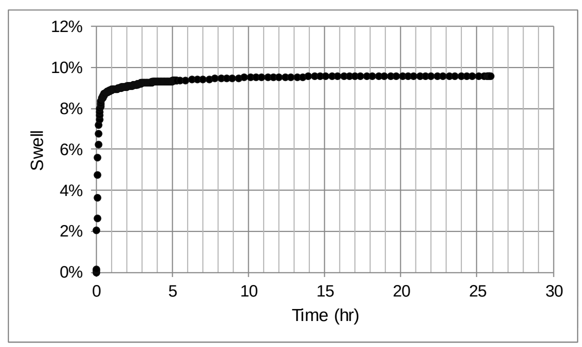
TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	6.00	7.50	gravity
Initial Moisture Content	24.0%	24.4%	%
Mass Soil Added	0.00	37.78	g
Dry Unit Weight	0.00	14.71	kN/m3
Height of Sample	1.000	0.999	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	-0.122	cm
Testing Height	0.999	1.095	cm
Void Ratio, e	0.827	1.002	-
Moisture Content	24.4%	38.6%	%
Saturation	81.0%	100.0%	%
Change in Moisture Content	-	14.2%	%
Overburden Mass	-	74.13	g
Height of Water	2.27	-	cm
Primary Swell	-	8.1%	%
Ultimate Swell	-	9.6%	%

NOTES	2% HL



Primary Swell (%)	8.1%		Ultimate Swell (%)	9.6%
Slope of Primary Swelling	11.05%	% per log cycle	Time to Swell (hr)	0.29
Slope of Secondary Swelling	0.41%	% per log cycle	Stress (psf)	68

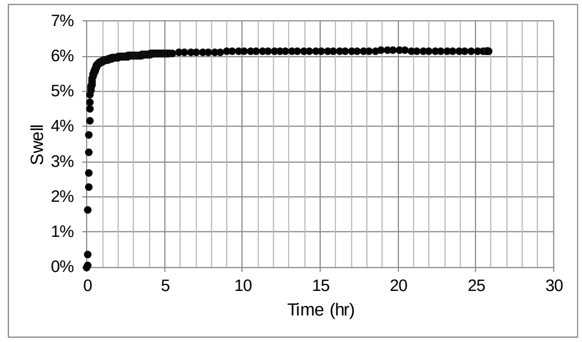
Date test conducted	1/2/1900
Centrifuge used	='Data Sheets'!I$1
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	7.50	gravity
	Initial Moisture Content	24.0%	24.2%	%
	Mass Soil Added	0.00	37.81	g
	Dry Unit Weight	0.00	14.75	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.130	cm
	Testing Height	0.999	1.061	cm
	Void Ratio, e	0.822	0.935	-
	Moisture Content	24.2%	35.9%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	11.7%	%
	Overburden Mass	-	140.55	g
	Height of Water	2.25	-	cm
	Primary Swell	-	5.5%	%
	Ultimate Swell	-	6.2%	%

NOTES	2% HL



Primary Swell (%)	5.5%	
Slope of Primary Swelling	4.62%	% per log cycle
Slope of Secondary Swelling	0.17%	% per log cycle

Ultimate Swell (%)	6.2%
Time to Swell (hr)	0.43
Stress (psf)	116

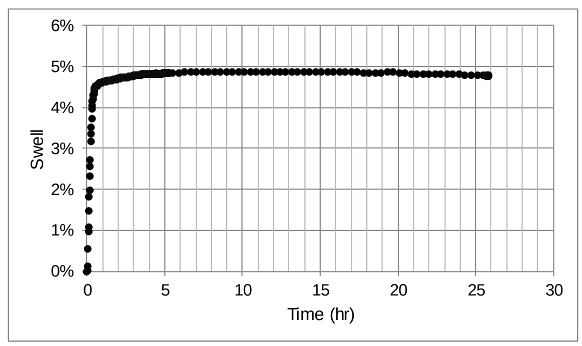
Date test conducted	6/14/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	7.50	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	0.00	37.82	g
	Dry Unit Weight	0.00	14.73	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.060	cm
	Testing Height	1.002	1.051	cm
	Void Ratio, e	0.824	0.913	-
	Moisture Content	24.0%	35.2%	%
	Saturation	79.8%	100.0%	%
	Change in Moisture Content	-	11.2%	%
	Overburden Mass	-	140.50	g
	Height of Water	2.27	-	cm
	Primary Swell	-	4.3%	%
	Ultimate Swell	-	4.9%	%

NOTES	2% HL



Primary Swell (%)	4.3%	
Slope of Primary Swelling	5.80%	% per log cycle
Slope of Secondary Swelling	0.07%	% per log cycle

Ultimate Swell (%)	4.9%
Time to Swell (hr)	0.43
Stress (psf)	116

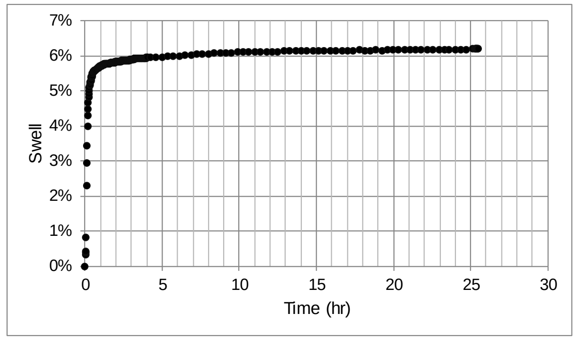
Date test conducted	6/12/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	28.20	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	0.00	37.72	g
	Dry Unit Weight	0.00	14.85	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.020	cm
	Testing Height	0.992	1.054	cm
	Void Ratio, e	0.809	0.922	-
	Moisture Content	23.9%	38.0%	%
	Saturation	80.8%	100.0%	%
	Change in Moisture Content	-	14.1%	%
	Overburden Mass	-	40.59	g
	Height of Water	2.26	-	cm
	Primary Swell	-	5.2%	%
	Ultimate Swell	-	6.2%	%

NOTES	2% HL



Primary Swell (%)	5.2%	
Slope of Primary Swelling	8.01%	% per log cycle
Slope of Secondary Swelling	0.35%	% per log cycle

Ultimate Swell (%)	6.2%
Time to Swell (hr)	0.30
Stress (psf)	163

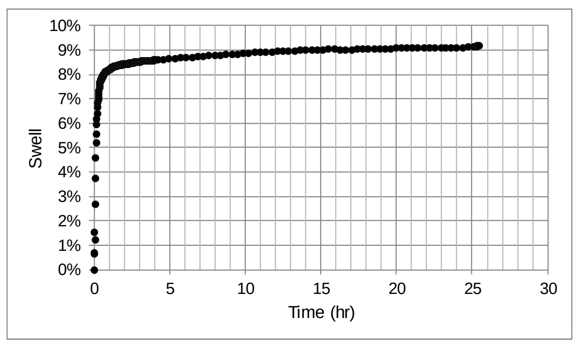
Date test conducted	6/12/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	28.20	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	0.00	37.76	g
	Dry Unit Weight	0.00	14.93	kN/m3
	Height of Sample	1.000	0.993	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.024	cm
	Testing Height	0.986	1.077	cm
	Void Ratio, e	0.800	0.965	-
	Moisture Content	24.1%	40.9%	%
	Saturation	82.5%	100.0%	%
	Change in Moisture Content	-	16.8%	%
	Overburden Mass	-	40.12	g
	Height of Water	2.29	-	cm
	Primary Swell	-	7.4%	%
	Ultimate Swell	-	9.2%	%

NOTES	2% HL



Primary Swell (%)	7.4%	
Slope of Primary Swelling	8.12%	% per log cycle
Slope of Secondary Swelling	0.65%	% per log cycle

Ultimate Swell (%)	9.2%
Time to Swell (hr)	0.36
Stress (psf)	162

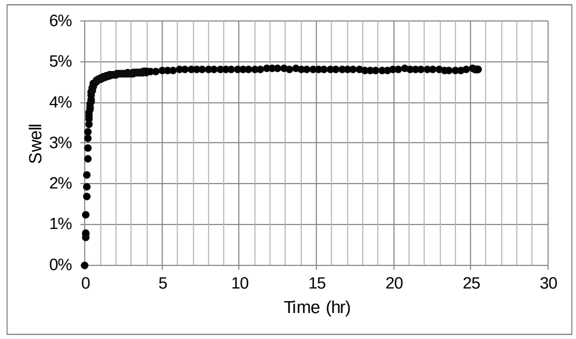
Date test conducted	6/12/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	28.20	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	0.00	37.79	g
	Dry Unit Weight	0.00	14.93	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.012	cm
	Testing Height	0.989	1.037	cm
	Void Ratio, e	0.800	0.887	-
	Moisture Content	23.8%	37.9%	%
	Saturation	81.6%	100.0%	%
	Change in Moisture Content	-	14.1%	%
	Overburden Mass	-	73.51	g
	Height of Water	2.28	-	cm
	Primary Swell	-	4.2%	%
	Ultimate Swell	-	4.8%	%

NOTES	2% HL



Primary Swell (%)	4.2%		
Ultimate Swell (%)	4.8%		
Slope of Primary Swelling	4.66%	% per log cycle	
Time to Swell (hr)	0.41		
Slope of Secondary Swelling	0.08%	% per log cycle	
Stress (psf)	254		

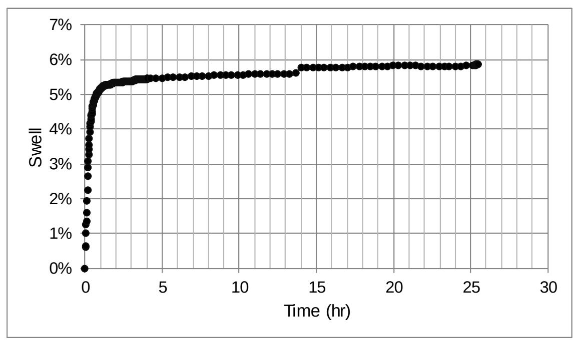
Date test conducted	6/12/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	28.20	gravity
	Initial Moisture Content	24.0%	24.2%	%
	Mass Soil Added	0.00	37.73	g
	Dry Unit Weight	0.00	14.82	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.019	cm
	Testing Height	0.992	1.050	cm
	Void Ratio, e	0.814	0.921	-
	Moisture Content	24.2%	39.2%	%
	Saturation	81.6%	100.0%	%
	Change in Moisture Content	-	15.0%	%
	Overburden Mass	-	73.68	g
	Height of Water	2.32	-	cm
	Primary Swell	-	4.7%	%
	Ultimate Swell	-	5.9%	%

NOTES	2% HL



Primary Swell (%)	4.7%		
Ultimate Swell (%)	5.9%		
Slope of Primary Swelling	4.73%	% per log cycle	
Time to Swell (hr)	0.53		
Slope of Secondary Swelling	0.53%	% per log cycle	
Stress (psf)	254		

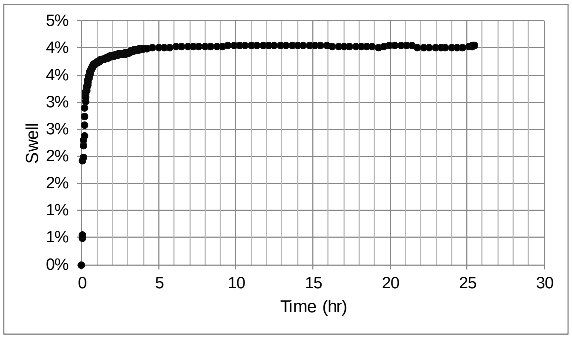
Date test conducted	6/12/2017	
Centrifuge used	3	
Cup Number	5	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	28.20	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	0.00	37.78	g
	Dry Unit Weight	0.00	14.93	kN/m3
	Height of Sample	1.000	0.995	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.008	cm
	Testing Height	0.988	1.029	cm
	Void Ratio, e	0.801	0.874	-
	Moisture Content	24.0%	37.1%	%
	Saturation	81.9%	100.0%	%
	Change in Moisture Content	-	13.2%	%
	Overburden Mass	-	140.55	g
	Height of Water	2.31	-	cm
	Primary Swell	-	3.5%	%
	Ultimate Swell	-	4.1%	%

NOTES	2% HL



Primary Swell (%)	3.5%		Ultimate Swell (%)	4.1%
Slope of Primary Swelling	2.27%	% per log cycle	Time to Swell (hr)	0.51
Slope of Secondary Swelling	0.15%	% per log cycle	Stress (psf)	437

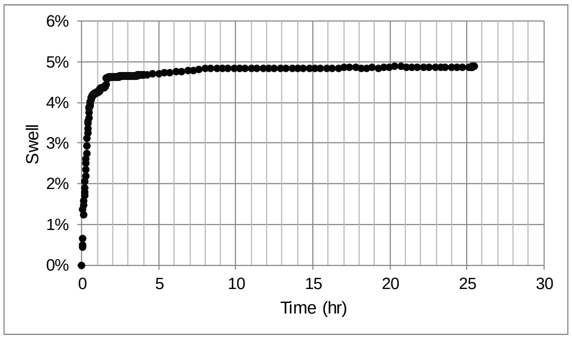
Date test conducted	6/12/2017	
Centrifuge used	3	
Cup Number	6	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	28.20	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	0.00	37.77	g
	Dry Unit Weight	0.00	14.91	kN/m3
	Height of Sample	1.000	0.993	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.017	cm
	Testing Height	0.988	1.036	cm
	Void Ratio, e	0.803	0.891	-
	Moisture Content	24.1%	35.9%	%
	Saturation	82.2%	100.0%	%
	Change in Moisture Content	-	11.8%	%
	Overburden Mass	-	140.59	g
	Height of Water	2.29	-	cm
	Primary Swell	-	4.2%	%
	Ultimate Swell	-	4.9%	%

NOTES	2% HL



Primary Swell (%)	4.2%		Ultimate Swell (%)	4.9%
Slope of Primary Swelling	3.37%	% per log cycle	Time to Swell (hr)	0.81
Slope of Secondary Swelling	0.26%	% per log cycle	Stress (psf)	437

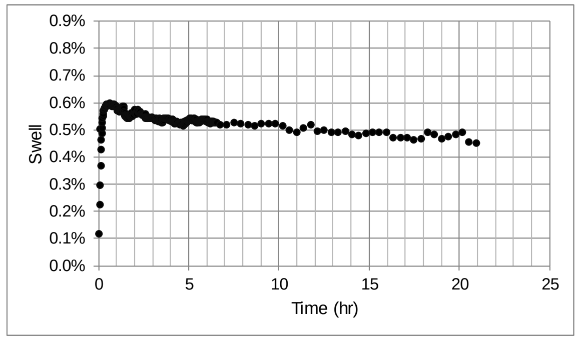
Date test conducted	9/27/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30+	33.68	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	38.00	37.95	g
	Dry Unit Weight	14.86	14.78	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.051	cm
	Testing Height	0.995	1.001	cm
	Void Ratio, e	0.819	0.830	-
	Moisture Content	24.9%	32.4%	%
	Saturation	83.3%	100.0%	%
	Change in Moisture Content	-	7.5%	%
	Overburden Mass	-	73.65	g
	Height of Water	2.28	-	cm
	Primary Swell	-	0.6%	%
	Ultimate Swell	-	0.6%	%

NOTES	2% HL



Primary Swell (%)	0.6%	
Slope of Primary Swelling	0.50%	% per log cycle
Slope of Secondary Swelling	-0.10%	% per log cycle

Ultimate Swell (%)	0.6%
Time to Swell (hr)	0.39
Stress (psf)	303

Date test conducted	
Centrifuge used	
Cup Number	
Conducted by	

SOIL Information		
	Soil	
	Target Water Content	
	Water Content	
	Specific Gravity	

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level			gravity
	Initial Moisture Content			%
	Mass Soil Added			g
	Dry Unit Weight			kN/m3
	Height of Sample			cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height			cm
	Testing Height			cm
	Void Ratio, e			-
	Moisture Content			%
	Saturation			%
	Change in Moisture Content			%
	Overburden Mass			g
	Height of Water			cm
	Primary Swell			%
	Ultimate Swell			%

NOTES	

Primary Swell (%)		
Slope of Primary Swelling		% per log cycle
Slope of Secondary Swelling		% per log cycle

Ultimate Swell (%)	
Time to Swell (hr)	
Stress (psf)	

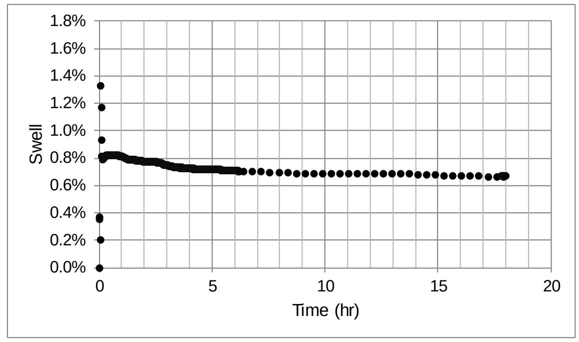
Date test conducted	9/10/2017
Centrifuge used	1
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	71.94	gravity
	Initial Moisture Content	24.0%	24.3%	%
	Mass Soil Added	37.94	37.85	g
	Dry Unit Weight	14.84	15.01	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.001	cm
	Testing Height	0.982	0.990	cm
	Void Ratio, e	0.791	0.805	-
	Moisture Content	24.3%	32.3%	%
	Saturation	84.2%	100.0%	%
	Change in Moisture Content	-	8.0%	%
	Overburden Mass	-	39.96	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	2% HL



Primary Swell (%)	0.8%	
Slope of Primary Swelling	1.24%	% per log cycle
Slope of Secondary Swelling	-0.10%	% per log cycle

Ultimate Swell (%)	0.8%
Time to Swell (hr)	0.21
Stress (psf)	410

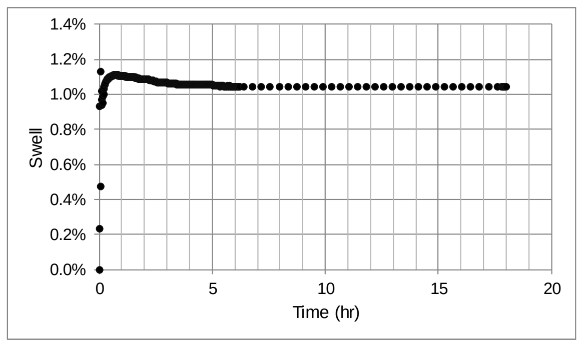
Date test conducted	9/10/2017
Centrifuge used	1
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	71.94	gravity
	Initial Moisture Content	24.0%	24.5%	%
	Mass Soil Added	37.91	37.83	g
	Dry Unit Weight	14.87	15.07	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.000	cm
	Testing Height	0.975	0.986	cm
	Void Ratio, e	0.783	0.803	-
	Moisture Content	24.5%	31.8%	%
	Saturation	85.8%	100.0%	%
	Change in Moisture Content	-	7.3%	%
	Overburden Mass	-	40.47	g
	Height of Water	2.31	-	cm
	Primary Swell	-	1.0%	%
	Ultimate Swell	-	1.1%	%

NOTES	2% HL



Primary Swell (%)	1.0%	
Slope of Primary Swelling	1.08%	% per log cycle
Slope of Secondary Swelling	-0.03%	% per log cycle

Ultimate Swell (%)	1.1%
Time to Swell (hr)	0.23
Stress (psf)	413

Date test conducted	9/10/2017
Centrifuge used	1
Cup Number	3
Conducted by	Karly

SOIL Information

Soil	EF
Target Water Content	24%
Water Content	25%
Specific Gravity	2.74

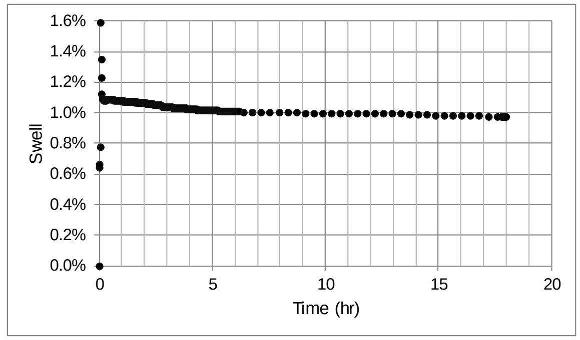
TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	75.00	71.94	gravity
Initial Moisture Content	24.0%	24.6%	%
Mass Soil Added	37.95	37.89	g
Dry Unit Weight	14.91	15.12	kN/m3
Height of Sample	1.000	0.994	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	0.000	cm
Testing Height	0.973	0.984	cm
Void Ratio, e	0.778	0.797	-
Moisture Content	24.6%	32.3%	%
Saturation	86.7%	100.0%	%
Change in Moisture Content	-	7.7%	%
Overburden Mass	-	73.80	g
Height of Water	2.30	-	cm
Primary Swell	-	1.1%	%
Ultimate Swell	-	1.1%	%

NOTES: 2% HL



Primary Swell (%)	1.1%	Ultimate Swell (%)	1.1%
Slope of Primary Swelling	0.65% % per log cycle	Time to Swell (hr)	0.21
Slope of Secondary Swelling	-0.08% % per log cycle	Stress (psf)	647

Date test conducted	9/10/2017
Centrifuge used	1
Cup Number	4
Conducted by	Karly

SOIL Information

Soil	EF
Target Water Content	24%
Water Content	25%
Specific Gravity	2.74

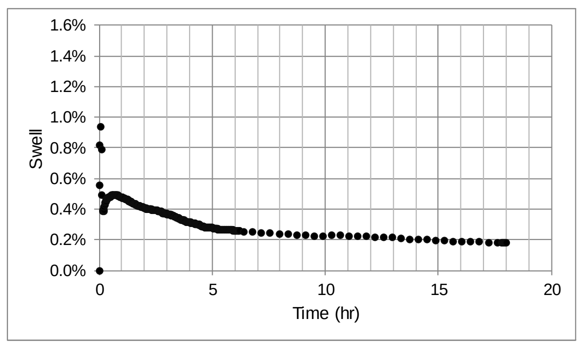
TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	75.00	71.94	gravity
Initial Moisture Content	24.0%	24.6%	%
Mass Soil Added	37.96	37.88	g
Dry Unit Weight	14.92	15.47	kN/m3
Height of Sample	1.000	0.993	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	-0.001	cm
Testing Height	0.951	0.956	cm
Void Ratio, e	0.738	0.746	-
Moisture Content	24.6%	32.9%	%
Saturation	91.4%	100.0%	%
Change in Moisture Content	-	8.3%	%
Overburden Mass	-	73.32	g
Height of Water	2.27	-	cm
Primary Swell	-	0.5%	%
Ultimate Swell	-	0.5%	%

NOTES: 2% HL



Primary Swell (%)	0.5%	Ultimate Swell (%)	0.5%
Slope of Primary Swelling	0.17% % per log cycle	Time to Swell (hr)	0.87
Slope of Secondary Swelling	-0.24% % per log cycle	Stress (psf)	643

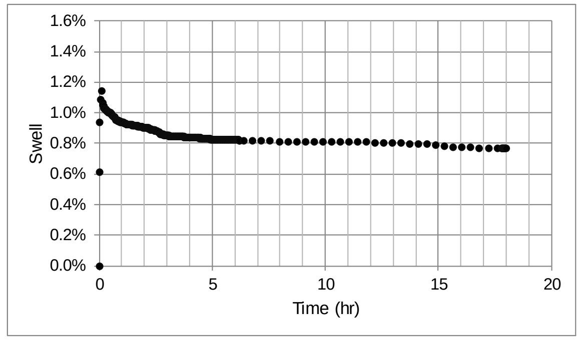
Date test conducted	9/10/2017
Centrifuge used	1
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	71.94	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	37.97	37.95	g
	Dry Unit Weight	14.89	15.23	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.000	cm
	Testing Height	0.965	0.975	cm
	Void Ratio, e	0.765	0.783	-
	Moisture Content	24.9%	32.6%	%
	Saturation	89.3%	100.0%	%
	Change in Moisture Content	-	7.7%	%
	Overburden Mass	-	140.55	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.6%	%
	Ultimate Swell	-	1.0%	%

NOTES	2% HL



Primary Swell (%)	0.6%	Ultimate Swell (%)	1.0%
Slope of Primary Swelling	-0.07% % per log cycle	Time to Swell (hr)	0.02
Slope of Secondary Swelling	-0.10% % per log cycle	Stress (psf)	1113

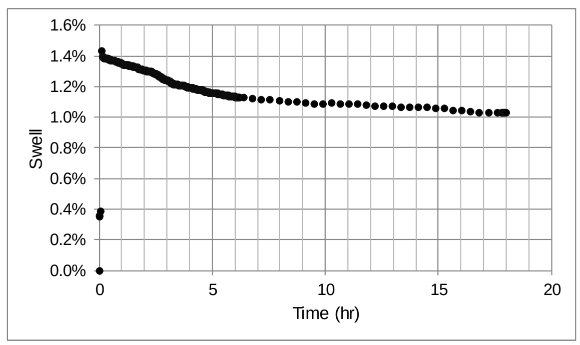
Date test conducted	9/10/2017
Centrifuge used	1
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	71.94	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	37.97	37.91	g
	Dry Unit Weight	14.89	15.21	kN/m3
	Height of Sample	1.000	0.996	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.000	cm
	Testing Height	0.966	0.980	cm
	Void Ratio, e	0.767	0.791	-
	Moisture Content	24.8%	32.0%	%
	Saturation	88.7%	100.0%	%
	Change in Moisture Content	-	7.2%	%
	Overburden Mass	-	140.80	g
	Height of Water	2.31	-	cm
	Primary Swell	-	1.4%	%
	Ultimate Swell	-	1.4%	%

NOTES	2% HL



Primary Swell (%)	1.4%	Ultimate Swell (%)	1.4%
Slope of Primary Swelling	2.11% % per log cycle	Time to Swell (hr)	0.21
Slope of Secondary Swelling	-0.27% % per log cycle	Stress (psf)	1115

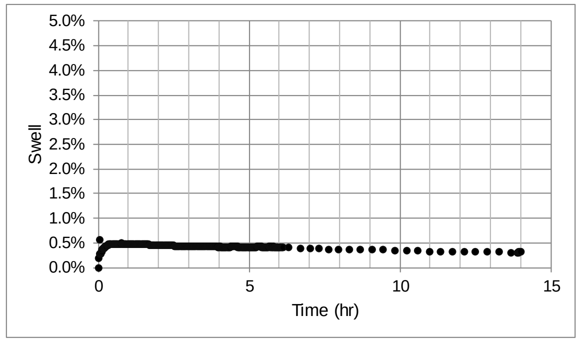
Date test conducted	2/5/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	120.00	118.05	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.02	37.96	g
	Dry Unit Weight	14.81	15.46	kN/m3
	Height of Sample	1.000	1.002	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.029	cm
	Testing Height	0.961	0.966	cm
	Void Ratio, e	0.739	0.748	-
	Moisture Content	23.7%	34.3%	%
	Saturation	87.8%	100.0%	%
	Change in Moisture Content	-	10.6%	%
	Overburden Mass	-	73.60	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.5%	%

NOTES	2% HL



Primary Swell (%)	0.5%	Ultimate Swell (%)	0.5%
Slope of Primary Swelling	0.26% % per log cycle	Time to Swell (hr)	0.87
Slope of Secondary Swelling	-0.20% % per log cycle	Stress (psf)	1060

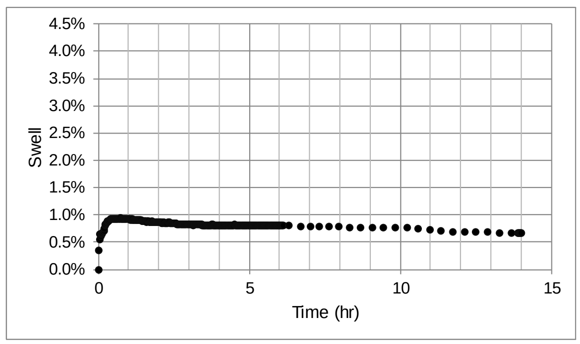
Date test conducted	2/5/2018
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	120.00	118.05	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	38.04	37.97	g
	Dry Unit Weight	14.84	15.38	kN/m3
	Height of Sample	1.000	1.001	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.054	cm
	Testing Height	0.969	0.978	cm
	Void Ratio, e	0.748	0.765	-
	Moisture Content	23.4%	33.2%	%
	Saturation	85.5%	100.0%	%
	Change in Moisture Content	-	9.8%	%
	Overburden Mass	-	73.07	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.9%	%
	Ultimate Swell	-	0.9%	%

NOTES	2% HL



Primary Swell (%)	0.9%	Ultimate Swell (%)	0.9%
Slope of Primary Swelling	0.43% % per log cycle	Time to Swell (hr)	0.54
Slope of Secondary Swelling	-0.17% % per log cycle	Stress (psf)	1055

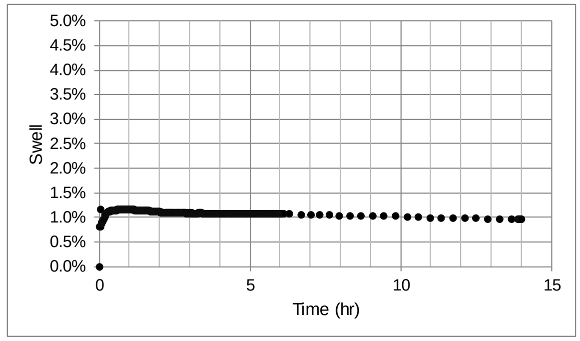
Date test conducted	2/5/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	120.00	118.05	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.00	37.93	g
	Dry Unit Weight	14.92	15.54	kN/m3
	Height of Sample	1.000	0.994	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.036	cm
	Testing Height	0.956	0.967	cm
	Void Ratio, e	0.729	0.749	-
	Moisture Content	23.6%	33.4%	%
	Saturation	88.5%	100.0%	%
	Change in Moisture Content	-	9.8%	%
	Overburden Mass	-	75.61	g
	Height of Water	2.63	-	cm
	Primary Swell	-	1.2%	%
	Ultimate Swell	-	1.2%	%

NOTES	2% HL



Primary Swell (%)	1.2%	Ultimate Swell (%)	1.2%
Slope of Primary Swelling	0.39% % per log cycle	Time to Swell (hr)	0.72
Slope of Secondary Swelling	-0.20% % per log cycle	Stress (psf)	1083

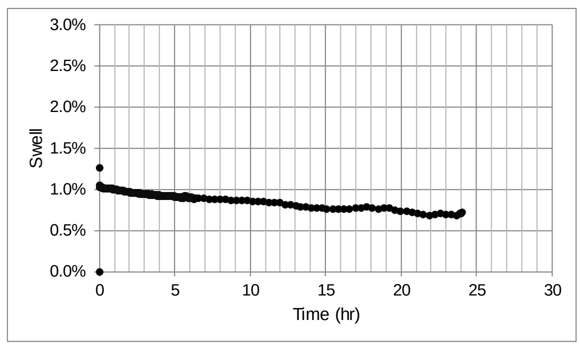
Date test conducted	2/8/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	236.91	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	38.00	37.85	g
	Dry Unit Weight	14.94	15.17	kN/m3
	Height of Sample	1.000	0.993	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.031	cm
	Testing Height	0.968	0.978	cm
	Void Ratio, e	0.772	0.790	-
	Moisture Content	24.8%	33.6%	%
	Saturation	87.8%	100.0%	%
	Change in Moisture Content	-	8.8%	%
	Overburden Mass	-	73.55	g
	Height of Water	2.63	-	cm
	Primary Swell	-	1.0%	%
	Ultimate Swell	-	1.0%	%

NOTES	2% HL



Primary Swell (%)	1.0%	Ultimate Swell (%)	1.0%
Slope of Primary Swelling	0.01% % per log cycle	Time to Swell (hr)	0.65
Slope of Secondary Swelling	-0.14% % per log cycle	Stress (psf)	2125

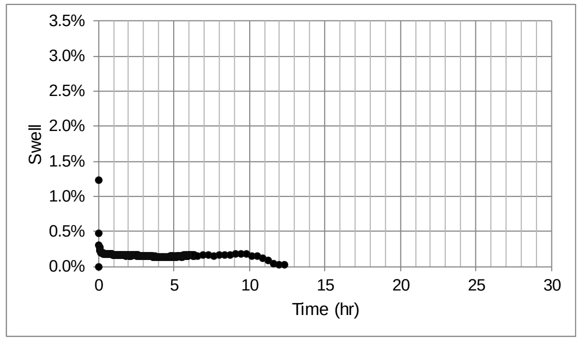
Date test conducted	2/8/2018	
Centrifuge used	3	
Cup Number	3	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	236.91	gravity
	Initial Moisture Content	24.0%	24.7%	%
	Mass Soil Added	37.99	37.77	g
	Dry Unit Weight	14.90	15.16	kN/m3
	Height of Sample	1.000	0.995	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.024	cm
	Testing Height	0.967	0.969	cm
	Void Ratio, e	0.773	0.777	-
	Moisture Content	24.7%	32.6%	%
	Saturation	87.7%	100.0%	%
	Change in Moisture Content	-	7.9%	%
	Overburden Mass	-	75.66	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.3%	%

NOTES	2% HL



Primary Swell (%)	0.2%	
Slope of Primary Swelling	-1.37%	% per log cycle
Slope of Secondary Swelling	0.01%	% per log cycle

Ultimate Swell (%)	0.3%
Time to Swell (hr)	0.12
Stress (psf)	2172

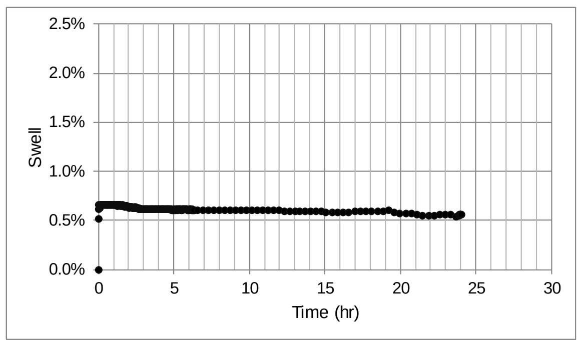
Date test conducted	2/8/2018	
Centrifuge used	3	
Cup Number	5	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	236.91	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	38.01	37.90	g
	Dry Unit Weight	14.99	15.17	kN/m3
	Height of Sample	1.000	0.990	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.023	cm
	Testing Height	0.971	0.977	cm
	Void Ratio, e	0.772	0.784	-
	Moisture Content	24.6%	33.3%	%
	Saturation	87.3%	100.0%	%
	Change in Moisture Content	-	8.7%	%
	Overburden Mass	-	73.54	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.7%	%
	Ultimate Swell	-	0.7%	%

NOTES	2% HL



Primary Swell (%)	0.7%	
Slope of Primary Swelling	0.16%	% per log cycle
Slope of Secondary Swelling	-0.07%	% per log cycle

Ultimate Swell (%)	0.7%
Time to Swell (hr)	0.29
Stress (psf)	2125

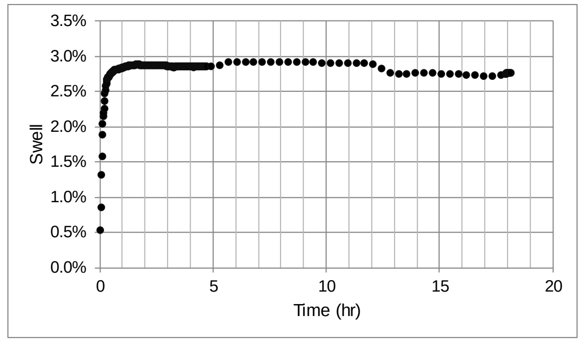
Date test conducted	7/23/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	16.91	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	38.06	37.85	g
	Dry Unit Weight	14.80	14.67	kN/m3
	Height of Sample	1.000	1.004	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.017	cm
	Testing Height	0.999	1.028	cm
	Void Ratio, e	0.832	0.886	-
	Moisture Content	25.0%	34.7%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	9.6%	%
	Overburden Mass	-	74.11	g
	Height of Water	2.62	-	cm
	Primary Swell	-	2.7%	%
	Ultimate Swell	-	2.9%	%

NOTES	
	2% HL; Lime After Water



Primary Swell (%)	2.7%
Ultimate Swell (%)	2.9%
Slope of Primary Swelling	2.39% % per log cycle
Time to Swell (hr)	0.34
Slope of Secondary Swelling	0.06% % per log cycle
Stress (psf)	153

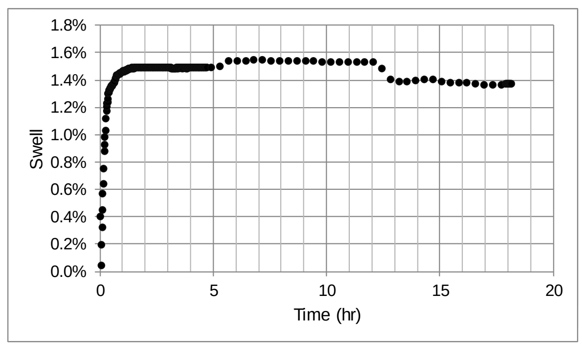
Date test conducted	7/23/2018
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	16.91	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.10	37.96	g
	Dry Unit Weight	14.87	14.92	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.007	cm
	Testing Height	0.995	1.011	cm
	Void Ratio, e	0.801	0.829	-
	Moisture Content	23.7%	33.7%	%
	Saturation	81.1%	100.0%	%
	Change in Moisture Content	-	10.0%	%
	Overburden Mass	-	73.68	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.3%	%
	Ultimate Swell	-	1.5%	%

NOTES	
	2% HL; Lime Before Water



Primary Swell (%)	1.3%
Ultimate Swell (%)	1.5%
Slope of Primary Swelling	1.61% % per log cycle
Time to Swell (hr)	0.43
Slope of Secondary Swelling	0.06% % per log cycle
Stress (psf)	152

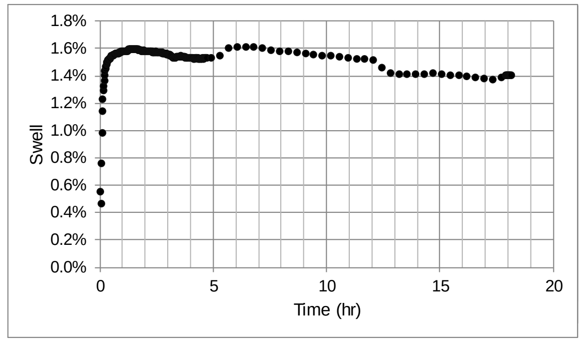
Date test conducted	7/23/2018
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	16.91	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	38.08	37.88	g
	Dry Unit Weight	14.86	14.85	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.023	cm
	Testing Height	0.988	1.004	cm
	Void Ratio, e	0.810	0.839	-
	Moisture Content	25.0%	35.2%	%
	Saturation	84.5%	100.0%	%
	Change in Moisture Content	-	10.2%	%
	Overburden Mass	-	74.34	g
	Height of Water	2.63	-	cm
	Primary Swell	-	1.5%	%
	Ultimate Swell	-	1.6%	%

NOTES	2% HL; Lime After Water



Primary Swell (%)	1.5%	Ultimate Swell (%)	1.6%
Slope of Primary Swelling	1.51% % per log cycle	Time to Swell (hr)	0.28
Slope of Secondary Swelling	-0.04% % per log cycle	Stress (psf)	153

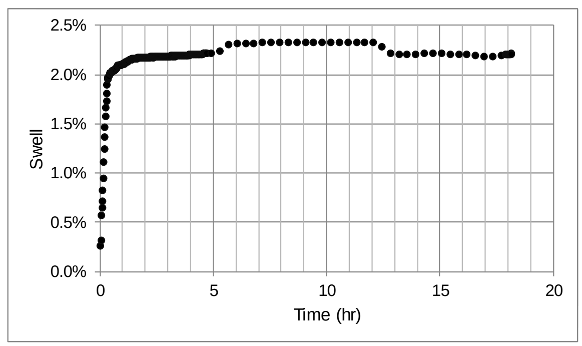
Date test conducted	7/23/2018
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	16.91	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.09	37.89	g
	Dry Unit Weight	14.80	14.84	kN/m3
	Height of Sample	1.000	1.004	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.001	cm
	Testing Height	0.999	1.022	cm
	Void Ratio, e	0.811	0.853	-
	Moisture Content	23.7%	33.5%	%
	Saturation	80.2%	100.0%	%
	Change in Moisture Content	-	9.8%	%
	Overburden Mass	-	73.72	g
	Height of Water	2.64	-	cm
	Primary Swell	-	2.0%	%
	Ultimate Swell	-	2.3%	%

NOTES	2% HL; Lime Before Water



Primary Swell (%)	2.0%	Ultimate Swell (%)	2.3%
Slope of Primary Swelling	2.02% % per log cycle	Time to Swell (hr)	0.41
Slope of Secondary Swelling	0.21% % per log cycle	Stress (psf)	152

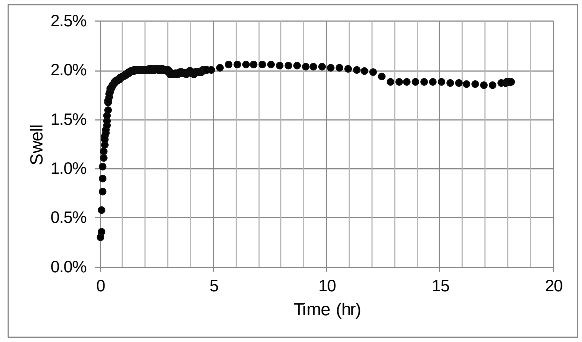
Date test conducted	7/23/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	16.91	gravity
	Initial Moisture Content	24.0%	25.3%	%
	Mass Soil Added	38.11	37.91	g
	Dry Unit Weight	14.80	14.69	kN/m3
	Height of Sample	1.000	1.005	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.008	cm
	Testing Height	0.997	1.018	cm
	Void Ratio, e	0.830	0.868	-
	Moisture Content	25.3%	34.3%	%
	Saturation	83.4%	100.0%	%
	Change in Moisture Content	-	9.0%	%
	Overburden Mass	-	73.46	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.8%	%
	Ultimate Swell	-	2.1%	%

NOTES	2% HL; Lime After Water



Primary Swell (%)	1.8%	Ultimate Swell (%)	2.1%
Slope of Primary Swelling	1.56% % per log cycle	Time to Swell (hr)	0.55
Slope of Secondary Swelling	0.07% % per log cycle	Stress (psf)	152

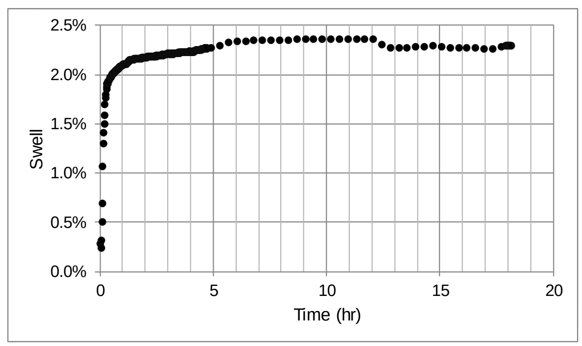
Date test conducted	7/23/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	16.91	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.07	37.88	g
	Dry Unit Weight	14.78	14.84	kN/m3
	Height of Sample	1.000	1.005	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.006	cm
	Testing Height	1.000	1.023	cm
	Void Ratio, e	0.812	0.855	-
	Moisture Content	23.6%	33.4%	%
	Saturation	79.8%	100.0%	%
	Change in Moisture Content	-	9.8%	%
	Overburden Mass	-	73.54	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.9%	%
	Ultimate Swell	-	2.4%	%

NOTES	2% HL; Lime Before Water



Primary Swell (%)	1.9%	Ultimate Swell (%)	2.4%
Slope of Primary Swelling	2.41% % per log cycle	Time to Swell (hr)	0.30
Slope of Secondary Swelling	0.26% % per log cycle	Stress (psf)	152

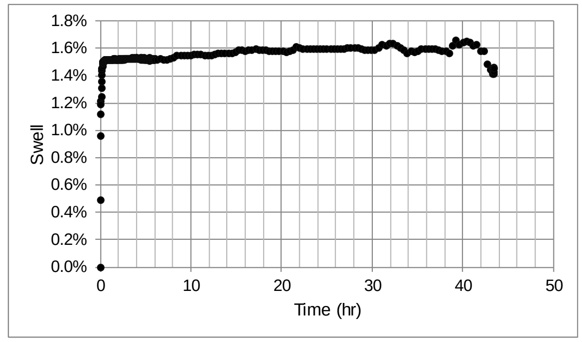
Date test conducted	4/14/2018	
Centrifuge used	3	
Cup Number	3	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	35.00	36.56	gravity
	Initial Moisture Content	24.0%	23.2%	%
	Mass Soil Added	38.03	37.88	g
	Dry Unit Weight	14.80	15.06	kN/m3
	Height of Sample	1.000	1.003	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.011	cm
	Testing Height	0.988	1.005	cm
	Void Ratio, e	0.785	0.814	-
	Moisture Content	23.2%	33.6%	%
	Saturation	81.0%	100.0%	%
	Change in Moisture Content	-	10.4%	%
	Overburden Mass	-	73.70	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.5%	%
	Ultimate Swell	-	1.7%	%

NOTES	2.5% HL



Primary Swell (%)	1.5%		Ultimate Swell (%)	1.7%
Slope of Primary Swelling	0.75%	% per log cycle	Time to Swell (hr)	0.24
Slope of Secondary Swelling	0.05%	% per log cycle	Stress (psf)	329

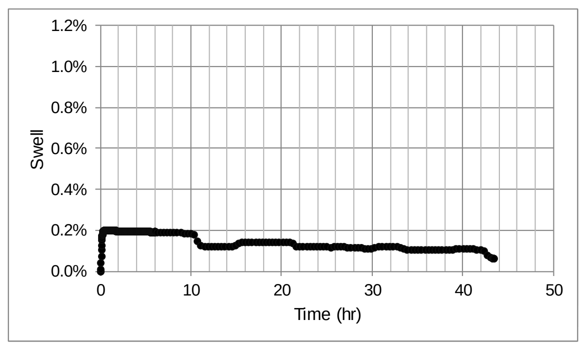
Date test conducted	4/14/2018	
Centrifuge used	3	
Cup Number	4	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	35.00	36.56	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	38.06	37.95	g
	Dry Unit Weight	14.84	15.03	kN/m3
	Height of Sample	1.000	1.001	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.004	cm
	Testing Height	0.990	0.992	cm
	Void Ratio, e	0.789	0.792	-
	Moisture Content	23.4%	33.6%	%
	Saturation	81.3%	100.0%	%
	Change in Moisture Content	-	10.2%	%
	Overburden Mass	-	73.75	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	2.5% HL



Primary Swell (%)	0.2%		Ultimate Swell (%)	0.2%
Slope of Primary Swelling	0.37%	% per log cycle	Time to Swell (hr)	0.30
Slope of Secondary Swelling	-0.05%	% per log cycle	Stress (psf)	329

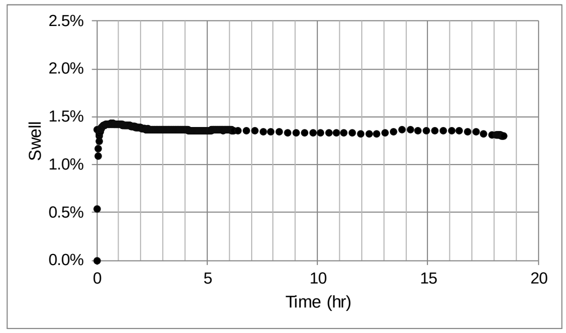
Date test conducted	4/13/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	35.00	34.99	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	38.07	37.92	g
	Dry Unit Weight	14.92	15.10	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.030	cm
	Testing Height	0.980	0.994	cm
	Void Ratio, e	0.780	0.805	-
	Moisture Content	24.0%	34.5%	%
	Saturation	84.4%	100.0%	%
	Change in Moisture Content	-	10.5%	%
	Overburden Mass	-	73.68	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.4%	%
	Ultimate Swell	-	1.4%	%

NOTES	3% HL



Primary Swell (%)	1.4%	
Slope of Primary Swelling	0.82%	% per log cycle
Slope of Secondary Swelling	-0.08%	% per log cycle

Ultimate Swell (%)	1.4%
Time to Swell (hr)	0.26
Stress (psf)	315

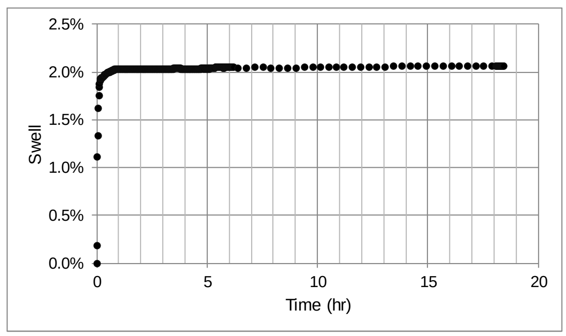
Date test conducted	4/13/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	35.00	34.99	gravity
	Initial Moisture Content	24.0%	24.5%	%
	Mass Soil Added	38.08	38.05	g
	Dry Unit Weight	14.86	14.90	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.011	cm
	Testing Height	0.993	1.013	cm
	Void Ratio, e	0.804	0.842	-
	Moisture Content	24.5%	35.2%	%
	Saturation	83.5%	100.0%	%
	Change in Moisture Content	-	10.7%	%
	Overburden Mass	-	74.31	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.9%	%
	Ultimate Swell	-	2.1%	%

NOTES	3% HL



Primary Swell (%)	1.9%	
Slope of Primary Swelling	2.13%	% per log cycle
Slope of Secondary Swelling	0.02%	% per log cycle

Ultimate Swell (%)	2.1%
Time to Swell (hr)	0.15
Stress (psf)	317

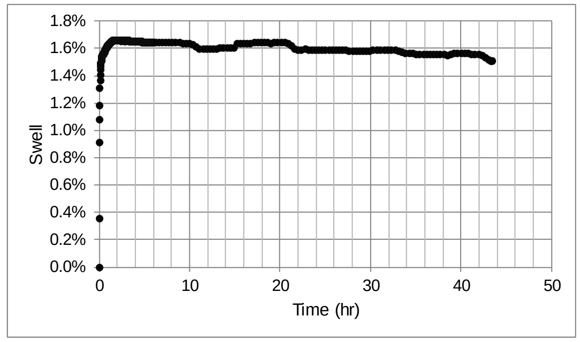
Date test conducted	4/14/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	36.56	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.04	37.97	g
	Dry Unit Weight	14.97	15.15	kN/m3
	Height of Sample	1.000	0.992	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.029	cm
	Testing Height	0.982	0.998	cm
	Void Ratio, e	0.774	0.804	-
	Moisture Content	23.6%	33.8%	%
	Saturation	83.5%	100.0%	%
	Change in Moisture Content	-	10.2%	%
	Overburden Mass	-	72.48	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.5%	%
	Ultimate Swell	-	1.7%	%

NOTES	3.5% HL



Primary Swell (%)	1.5%			Ultimate Swell (%)	1.7%
Slope of Primary Swelling	0.70%	% per log cycle		Time to Swell (hr)	0.36
Slope of Secondary Swelling	0.00%	% per log cycle		Stress (psf)	325

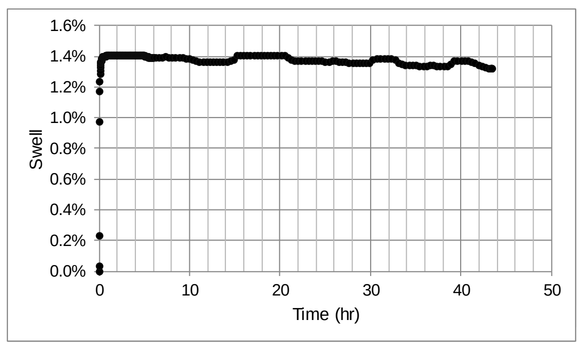
Date test conducted	4/14/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	35.00	36.56	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	38.06	38.02	g
	Dry Unit Weight	14.81	14.85	kN/m3
	Height of Sample	1.000	1.003	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.009	cm
	Testing Height	1.001	1.015	cm
	Void Ratio, e	0.810	0.835	-
	Moisture Content	23.8%	34.2%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	10.4%	%
	Overburden Mass	-	74.33	g
	Height of Water	2.62	-	cm
	Primary Swell	-	1.4%	%
	Ultimate Swell	-	1.4%	%

NOTES	3.5% HL



Primary Swell (%)	1.4%			Ultimate Swell (%)	1.4%
Slope of Primary Swelling	0.43%	% per log cycle		Time to Swell (hr)	0.26
Slope of Secondary Swelling	0.00%	% per log cycle		Stress (psf)	332

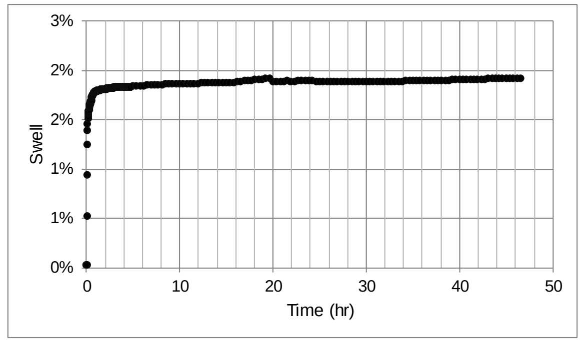
Date test conducted	5/23/2017
Centrifuge used	1
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	11.12	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	0.00	37.69	g
	Dry Unit Weight	0.00	14.85	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.016	cm
	Testing Height	0.991	1.010	cm
	Void Ratio, e	0.811	0.845	-
	Moisture Content	24.0%	33.9%	%
	Saturation	81.1%	100.0%	%
	Change in Moisture Content	-	9.9%	%
	Overburden Mass	-	40.54	g
	Height of Water	2.27	-	cm
	Primary Swell	-	1.5%	%
	Ultimate Swell	-	1.9%	%

NOTES	4% HL



Primary Swell (%)	1.5%			Ultimate Swell (%)	1.9%
Slope of Primary Swelling	1.95%	% per log cycle		Time to Swell (hr)	0.15
Slope of Secondary Swelling	0.11%	% per log cycle		Stress (psf)	64

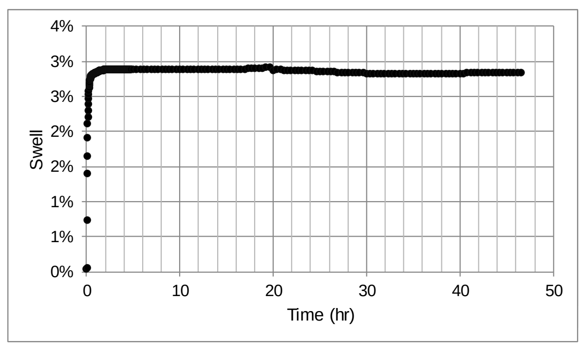
Date test conducted	5/23/2017
Centrifuge used	1
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	11.12	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	0.00	37.76	g
	Dry Unit Weight	0.00	14.86	kN/m3
	Height of Sample	1.000	0.992	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.040	cm
	Testing Height	0.992	1.021	cm
	Void Ratio, e	0.809	0.862	-
	Moisture Content	24.0%	33.9%	%
	Saturation	81.3%	100.0%	%
	Change in Moisture Content	-	9.9%	%
	Overburden Mass	-	39.90	g
	Height of Water	2.27	-	cm
	Primary Swell	-	2.6%	%
	Ultimate Swell	-	2.9%	%

NOTES	4% HL



Primary Swell (%)	2.6%			Ultimate Swell (%)	2.9%
Slope of Primary Swelling	2.66%	% per log cycle		Time to Swell (hr)	0.23
Slope of Secondary Swelling	0.04%	% per log cycle		Stress (psf)	63

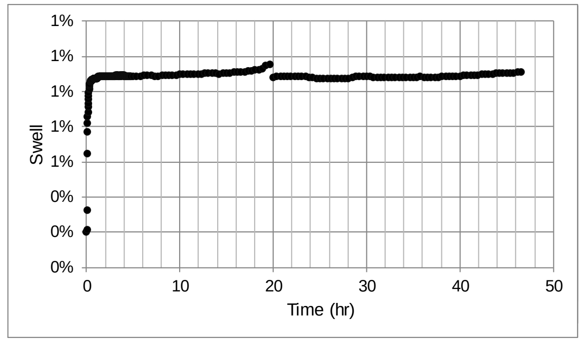
Date test conducted	5/23/2017
Centrifuge used	1
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	11.12	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	0.00	37.76	g
	Dry Unit Weight	0.00	14.84	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.033	cm
	Testing Height	0.994	1.006	cm
	Void Ratio, e	0.812	0.833	-
	Moisture Content	23.9%	34.0%	%
	Saturation	80.8%	100.0%	%
	Change in Moisture Content	-	10.1%	%
	Overburden Mass	-	75.19	g
	Height of Water	2.28	-	cm
	Primary Swell	-	1.1%	%
	Ultimate Swell	-	1.2%	%

NOTES	4% HL



Primary Swell (%)	1.1%		Ultimate Swell (%)	1.2%
Slope of Primary Swelling	0.45%	% per log cycle	Time to Swell (hr)	0.38
Slope of Secondary Swelling	0.00%	% per log cycle	Stress (psf)	102

Date test conducted	
Centrifuge used	
Cup Number	
Conducted by	

SOIL Information		
	Soil	
	Target Water Content	
	Water Content	
	Specific Gravity	

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level			gravity
	Initial Moisture Content			%
	Mass Soil Added			gravity
	Dry Unit Weight			kN/m3
	Height of Sample			cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height			cm
	Testing Height			cm
	Void Ratio, e			-
	Moisture Content			%
	Saturation			%
	Change in Moisture Content			%
	Overburden Mass			g
	Height of Water			cm
	Primary Swell			%
	Ultimate Swell			%

NOTES	

Primary Swell (%)			Ultimate Swell (%)	
Slope of Primary Swelling		% per log cycle	Time to Swell (hr)	
Slope of Secondary Swelling		% per log cycle	Stress (psf)	

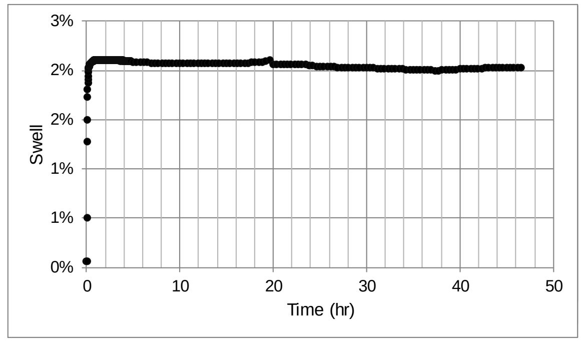
Date test conducted	5/23/2017
Centrifuge used	1
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	11.12	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	0.00	37.81	g
	Dry Unit Weight	0.00	14.88	kN/m3
	Height of Sample	1.000	0.993	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.039	cm
	Testing Height	0.992	1.013	cm
	Void Ratio, e	0.806	0.844	-
	Moisture Content	23.9%	33.1%	%
	Saturation	81.3%	100.0%	%
	Change in Moisture Content	-	9.2%	%
	Overburden Mass	-	140.57	g
	Height of Water	2.28	-	cm
	Primary Swell	-	2.0%	%
	Ultimate Swell	-	2.1%	%

NOTES	4% HL



Primary Swell (%)	2.0%		Ultimate Swell (%)	2.1%
Slope of Primary Swelling	1.63%	% per log cycle	Time to Swell (hr)	0.19
Slope of Secondary Swelling	0.00%	% per log cycle	Stress (psf)	172

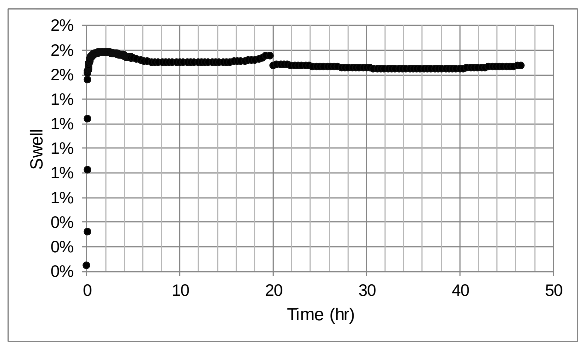
Date test conducted	5/23/2017
Centrifuge used	1
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	6.00	11.12	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	0.00	37.85	g
	Dry Unit Weight	0.00	14.92	kN/m3
	Height of Sample	1.000	0.992	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.021	cm
	Testing Height	0.992	1.010	cm
	Void Ratio, e	0.802	0.834	-
	Moisture Content	23.8%	33.3%	%
	Saturation	81.4%	100.0%	%
	Change in Moisture Content	-	9.5%	%
	Overburden Mass	-	140.53	g
	Height of Water	2.27	-	cm
	Primary Swell	-	1.6%	%
	Ultimate Swell	-	1.8%	%

NOTES	4% HL



Primary Swell (%)	1.6%		Ultimate Swell (%)	1.8%
Slope of Primary Swelling	1.85%	% per log cycle	Time to Swell (hr)	0.13
Slope of Secondary Swelling	-0.02%	% per log cycle	Stress (psf)	172

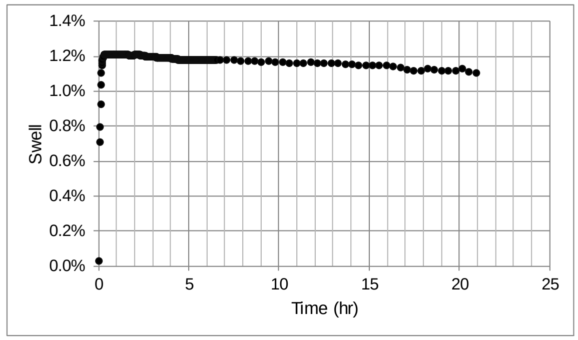
Date test conducted	9/27/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30+	33.68	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	38.07	38.01	g
	Dry Unit Weight	14.86	14.71	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.190	cm
	Testing Height	1.001	1.013	cm
	Void Ratio, e	0.827	0.849	-
	Moisture Content	25.0%	31.7%	%
	Saturation	82.7%	100.0%	%
	Change in Moisture Content	-	6.8%	%
	Overburden Mass	-	73.25	g
	Height of Water	2.30	-	cm
	Primary Swell	-	1.2%	%
	Ultimate Swell	-	1.2%	%

NOTES	4% HL



Primary Swell (%)	1.2%	
Ultimate Swell (%)	1.2%	
Slope of Primary Swelling	1.79%	% per log cycle
Time to Swell (hr)	0.21	
Slope of Secondary Swelling	-0.11%	% per log cycle
Stress (psf)	302	

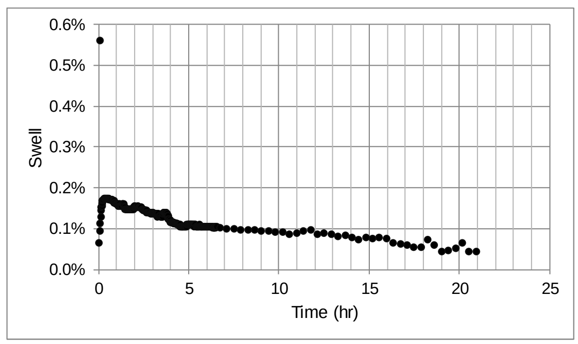
Date test conducted	9/27/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30+	33.68	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	38.02	37.99	g
	Dry Unit Weight	14.82	14.78	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.078	cm
	Testing Height	0.997	0.998	cm
	Void Ratio, e	0.818	0.821	-
	Moisture Content	24.8%	31.7%	%
	Saturation	83.1%	100.0%	%
	Change in Moisture Content	-	6.9%	%
	Overburden Mass	-	75.78	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	4% HL



Primary Swell (%)	0.2%	
Ultimate Swell (%)	0.2%	
Slope of Primary Swelling	0.16%	% per log cycle
Time to Swell (hr)	0.50	
Slope of Secondary Swelling	-0.11%	% per log cycle
Stress (psf)	310	

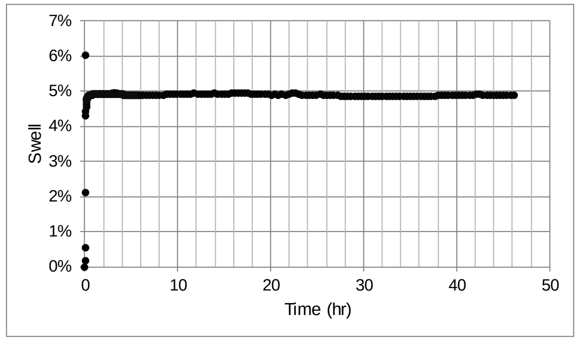
Date test conducted	5/23/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.31	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	0.00	37.73	g
	Dry Unit Weight	0.00	14.89	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.165	cm
	Testing Height	0.992	1.041	cm
	Void Ratio, e	0.806	0.895	-
	Moisture Content	23.7%	34.8%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	11.1%	%
	Overburden Mass	-	41.26	g
	Height of Water	2.29	-	cm
	Primary Swell	-	4.9%	%
	Ultimate Swell	-	4.9%	%

NOTES	4% HL



Primary Swell (%)	4.9%	
Slope of Primary Swelling	0.95%	% per log cycle
Slope of Secondary Swelling	-0.02%	% per log cycle

Ultimate Swell (%)	4.9%
Time to Swell (hr)	0.43
Stress (psf)	189

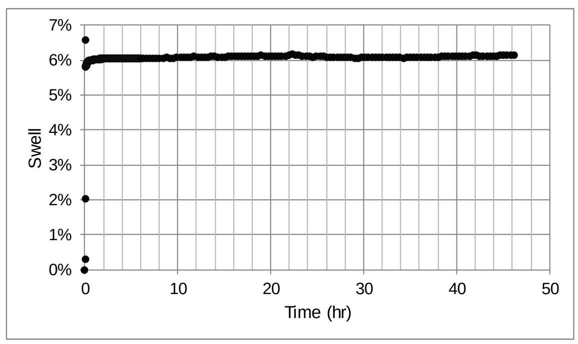
Date test conducted	5/23/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.31	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	0.00	37.72	g
	Dry Unit Weight	0.00	14.83	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.689	cm
	Testing Height	0.997	1.059	cm
	Void Ratio, e	0.813	0.924	-
	Moisture Content	23.5%	34.9%	%
	Saturation	79.1%	100.0%	%
	Change in Moisture Content	-	11.5%	%
	Overburden Mass	-	40.18	g
	Height of Water	2.30	-	cm
	Primary Swell	-	6.0%	%
	Ultimate Swell	-	6.2%	%

NOTES	4% HL



Primary Swell (%)	6.0%	
Slope of Primary Swelling	0.30%	% per log cycle
Slope of Secondary Swelling	0.08%	% per log cycle

Ultimate Swell (%)	6.2%
Time to Swell (hr)	0.43
Stress (psf)	186

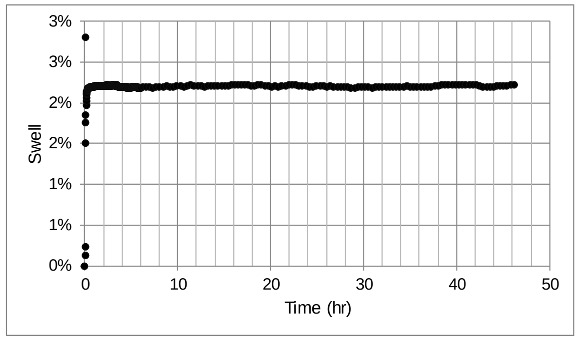
Date test conducted	5/23/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.31	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	0.00	37.78	g
	Dry Unit Weight	0.00	14.97	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.083	cm
	Testing Height	0.990	1.012	cm
	Void Ratio, e	0.796	0.836	-
	Moisture Content	23.4%	33.5%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	10.0%	%
	Overburden Mass	-	73.56	g
	Height of Water	2.28	-	cm
	Primary Swell	-	2.1%	%
	Ultimate Swell	-	2.2%	%

NOTES	4% HL



Primary Swell (%)	2.1%	Ultimate Swell (%)	2.2%
Slope of Primary Swelling	1.20% % per log cycle	Time to Swell (hr)	0.23
Slope of Secondary Swelling	-0.01% % per log cycle	Stress (psf)	291

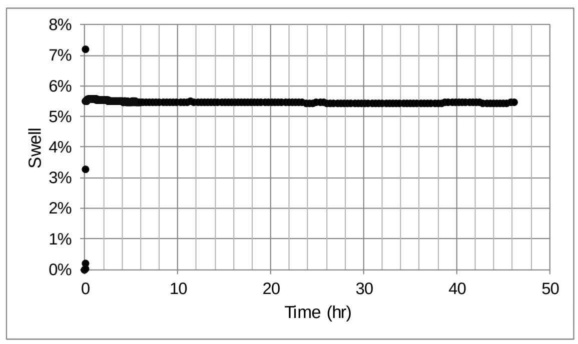
Date test conducted	5/23/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.31	gravity
	Initial Moisture Content	24.0%	22.8%	%
	Mass Soil Added	0.00	37.71	g
	Dry Unit Weight	0.00	15.04	kN/m3
	Height of Sample	1.000	0.990	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.053	cm
	Testing Height	0.988	1.043	cm
	Void Ratio, e	0.787	0.886	-
	Moisture Content	22.8%	34.0%	%
	Saturation	79.2%	100.0%	%
	Change in Moisture Content	-	11.2%	%
	Overburden Mass	-	74.19	g
	Height of Water	2.27	-	cm
	Primary Swell	-	5.5%	%
	Ultimate Swell	-	5.6%	%

NOTES	4% HL



Primary Swell (%)	5.5%	Ultimate Swell (%)	5.6%
Slope of Primary Swelling	13.82% % per log cycle	Time to Swell (hr)	0.11
Slope of Secondary Swelling	-0.08% % per log cycle	Stress (psf)	293

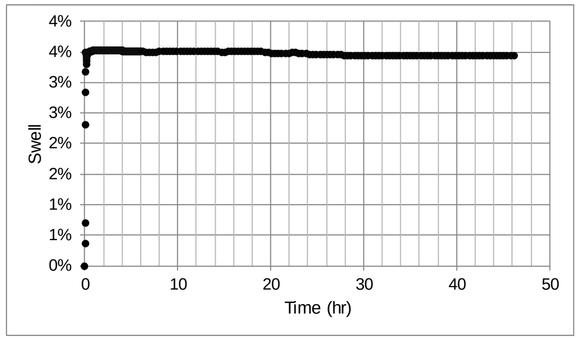
Date test conducted	5/23/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.31	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	0.00	37.65	g
	Dry Unit Weight	0.00	14.92	kN/m3
	Height of Sample	1.000	0.990	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.161	cm
	Testing Height	0.989	1.024	cm
	Void Ratio, e	0.802	0.866	-
	Moisture Content	23.6%	33.2%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	9.6%	%
	Overburden Mass	-	141.32	g
	Height of Water	2.29	-	cm
	Primary Swell	-	3.4%	%
	Ultimate Swell	-	3.5%	%

NOTES	4% HL



Primary Swell (%)	3.4%	Ultimate Swell (%)	3.5%
Slope of Primary Swelling	2.45% % per log cycle	Time to Swell (hr)	0.19
Slope of Secondary Swelling	-0.04% % per log cycle	Stress (psf)	503

Date test conducted	
Centrifuge used	
Cup Number	
Conducted by	

SOIL Information		
	Soil	
	Target Water Content	
	Water Content	
	Specific Gravity	

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level			gravity
	Initial Moisture Content			%
	Mass Soil Added			g
	Dry Unit Weight			kN/m3
	Height of Sample			cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height			cm
	Testing Height			cm
	Void Ratio, e			-
	Moisture Content			%
	Saturation			%
	Change in Moisture Content			%
	Overburden Mass			g
	Height of Water			cm
	Primary Swell			%
	Ultimate Swell			%

NOTES	

Primary Swell (%)		Ultimate Swell (%)	
Slope of Primary Swelling	% per log cycle	Time to Swell (hr)	
Slope of Secondary Swelling	% per log cycle	Stress (psf)	

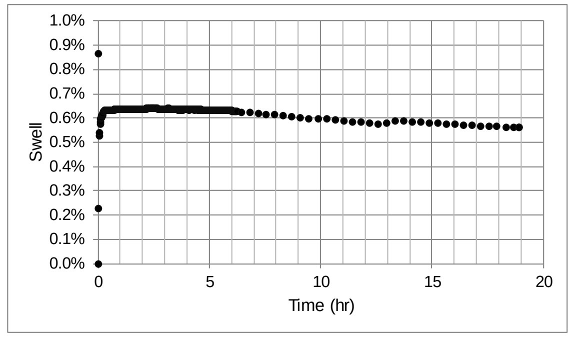
Date test conducted	9/11/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	70.23	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	37.94	37.84	g
	Dry Unit Weight	14.92	14.81	kN/m3
	Height of Sample	1.000	0.993	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.033	cm
	Testing Height	0.991	0.997	cm
	Void Ratio, e	0.815	0.827	-
	Moisture Content	24.8%	31.9%	%
	Saturation	83.4%	100.0%	%
	Change in Moisture Content	-	7.1%	%
	Overburden Mass	-	39.45	g
	Height of Water	2.27	-	cm
	Primary Swell	-	0.6%	%
	Ultimate Swell	-	0.6%	%

NOTES	4% HL



Primary Swell (%)	0.6%	Ultimate Swell (%)	0.6%
Slope of Primary Swelling	0.40% % per log cycle	Time to Swell (hr)	0.45
Slope of Secondary Swelling	-0.13% % per log cycle	Stress (psf)	396

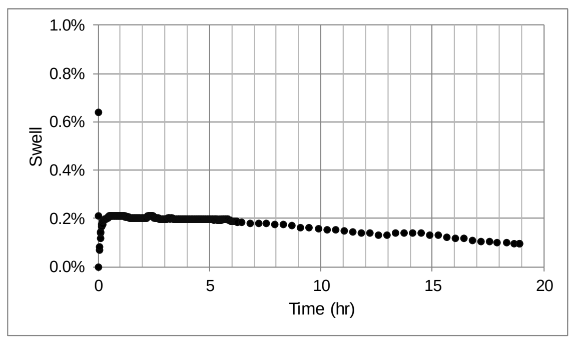
Date test conducted	9/11/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	70.23	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	37.98	37.92	g
	Dry Unit Weight	14.87	14.89	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.010	cm
	Testing Height	0.986	0.989	cm
	Void Ratio, e	0.805	0.809	-
	Moisture Content	24.9%	32.3%	%
	Saturation	84.9%	100.0%	%
	Change in Moisture Content	-	7.3%	%
	Overburden Mass	-	40.10	g
	Height of Water	2.29	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	4% HL



Primary Swell (%)	0.2%	Ultimate Swell (%)	0.2%
Slope of Primary Swelling	0.22% % per log cycle	Time to Swell (hr)	0.89
Slope of Secondary Swelling	-0.18% % per log cycle	Stress (psf)	401

Date test conducted	
Centrifuge used	
Cup Number	
Conducted by	

SOIL Information		
	Soil	
	Target Water Content	
	Water Content	
	Specific Gravity	

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level			gravity
	Initial Moisture Content			%
	Mass Soil Added			gravity
	Dry Unit Weight			kN/m3
	Height of Sample			cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height			cm
	Testing Height			cm
	Void Ratio, e			-
	Moisture Content			%
	Saturation			%
	Change in Moisture Content			%
	Overburden Mass			g
	Height of Water			cm
	Primary Swell			%
	Ultimate Swell			%

Primary Swell (%)	
Ultimate Swell (%)	
Slope of Primary Swelling	% per log cycle
Time to Swell (hr)	
Slope of Secondary Swelling	% per log cycle
Stress (psf)	

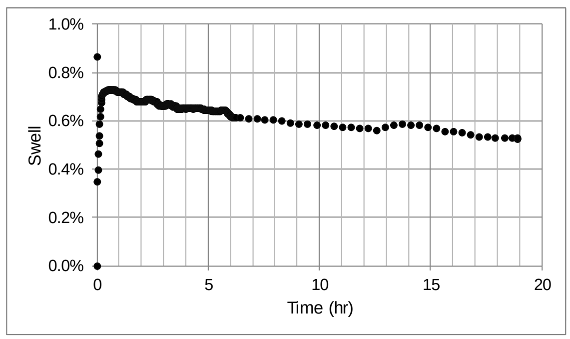
NOTES	4% HL

Date test conducted	9/11/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	75.00	70.23	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	37.93	37.87	g
	Dry Unit Weight	14.85	14.90	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.046	cm
	Testing Height	0.985	0.992	cm
	Void Ratio, e	0.803	0.817	-
	Moisture Content	24.9%	32.5%	%
	Saturation	84.9%	100.0%	%
	Change in Moisture Content	-	7.6%	%
	Overburden Mass	-	75.59	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.7%	%
	Ultimate Swell	-	0.7%	%



Primary Swell (%)	0.7%
Ultimate Swell (%)	0.7%
Slope of Primary Swelling	0.53% % per log cycle
Time to Swell (hr)	0.45
Slope of Secondary Swelling	-0.20% % per log cycle
Stress (psf)	644

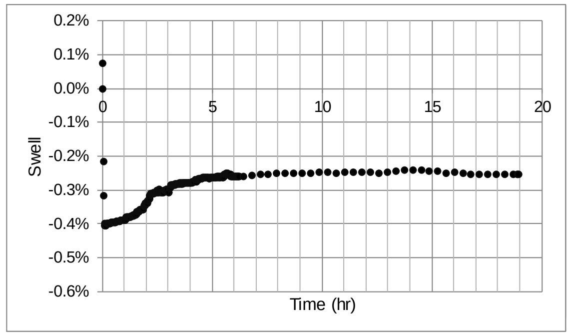
NOTES	4% HL

	Date test conducted	9/11/2017	
	Centrifuge used	2	
	Cup Number	5	
	Conducted by	Karly	
SOIL Information	Soil	EF	
	Target Water Content	24%	
	Water Content	25%	
	Specific Gravity	2.74	

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	75.00	70.23	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	37.94	37.90	g
	Dry Unit Weight	14.98	14.85	kN/m3
	Height of Sample	1.000	0.989	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.118	cm
	Testing Height	0.988	0.985	cm
	Void Ratio, e	0.810	0.805	-
	Moisture Content	25.0%	32.5%	%
	Saturation	84.7%	100.0%	%
	Change in Moisture Content	-	7.5%	%
	Overburden Mass	-	140.40	g
	Height of Water	2.28	-	cm
	Primary Swell	-	-0.4%	%
	Ultimate Swell	-	-0.2%	%

NOTES	4% HL



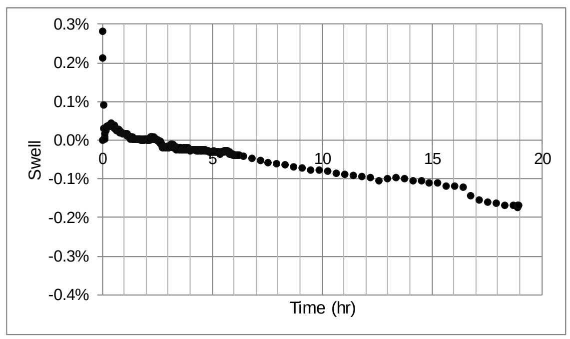
Primary Swell (%)	-0.4%	Ultimate Swell (%)	-0.2%
Slope of Primary Swelling	-0.50% % per log cycle	Time to Swell (hr)	0.12
Slope of Secondary Swelling	0.02% % per log cycle	Stress (psf)	1085

	Date test conducted	9/11/2017	
	Centrifuge used	2	
	Cup Number	6	
	Conducted by	Karly	
SOIL Information	Soil	EF	
	Target Water Content	24%	
	Water Content	25%	
	Specific Gravity	2.74	

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	75.00	70.23	gravity
	Initial Moisture Content	24.0%	25.2%	%
	Mass Soil Added	37.93	37.86	g
	Dry Unit Weight	14.80	14.92	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.024	cm
	Testing Height	0.981	0.982	cm
	Void Ratio, e	0.802	0.802	-
	Moisture Content	25.2%	33.4%	%
	Saturation	86.0%	100.0%	%
	Change in Moisture Content	-	8.2%	%
	Overburden Mass	-	141.72	g
	Height of Water	2.27	-	cm
	Primary Swell	-	0.0%	%
	Ultimate Swell	-	0.0%	%

NOTES	4% HL



Primary Swell (%)	0.0%	Ultimate Swell (%)	0.0%
Slope of Primary Swelling	-0.27% % per log cycle	Time to Swell (hr)	0.10
Slope of Secondary Swelling	-0.02% % per log cycle	Stress (psf)	1094

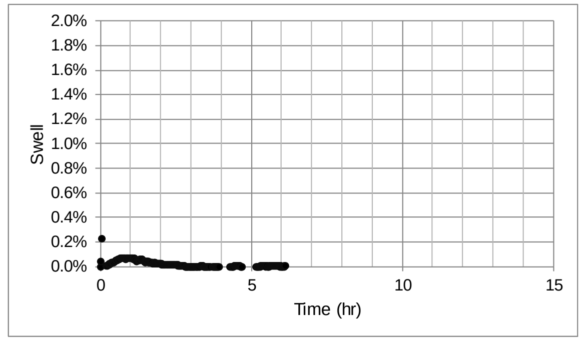
Date test conducted	2/5/2018	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	120.00	118.05	gravity
	Initial Moisture Content	24.0%	22.7%	%
	Mass Soil Added	38.04	37.99	g
	Dry Unit Weight	14.96	15.36	kN/m3
	Height of Sample	1.000	0.993	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.015	cm
	Testing Height	0.976	0.977	cm
	Void Ratio, e	0.750	0.751	-
	Moisture Content	22.7%	32.1%	%
	Saturation	82.8%	100.0%	%
	Change in Moisture Content	-	9.5%	%
	Overburden Mass	-	73.73	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.1%	%
	Ultimate Swell	-	0.1%	%

NOTES	4% HL



Primary Swell (%)	0.1%		Ultimate Swell (%)	0.1%
Slope of Primary Swelling	0.12%	% per log cycle	Time to Swell (hr)	0.60
Slope of Secondary Swelling	-0.06%	% per log cycle	Stress (psf)	1063

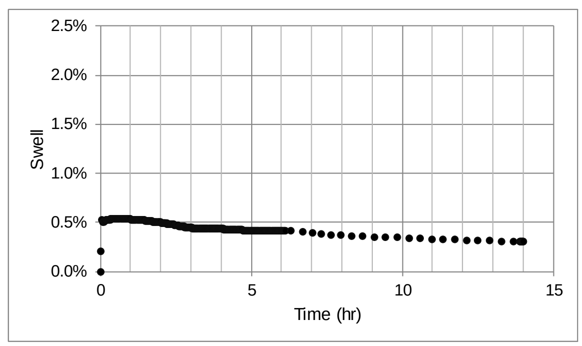
Date test conducted	2/5/2018	
Centrifuge used	3	
Cup Number	4	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	120.00	118.05	gravity
	Initial Moisture Content	24.0%	22.7%	%
	Mass Soil Added	38.04	37.98	g
	Dry Unit Weight	14.86	15.32	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.007	cm
	Testing Height	0.978	0.983	cm
	Void Ratio, e	0.754	0.764	-
	Moisture Content	22.7%	32.6%	%
	Saturation	82.5%	100.0%	%
	Change in Moisture Content	-	9.9%	%
	Overburden Mass	-	73.52	g
	Height of Water	2.65	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.5%	%

NOTES	4% HL



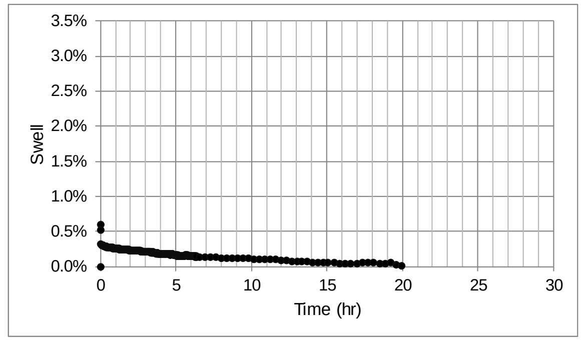
Primary Swell (%)	0.5%		Ultimate Swell (%)	0.5%
Slope of Primary Swelling	0.04%	% per log cycle	Time to Swell (hr)	1.28
Slope of Secondary Swelling	-0.24%	% per log cycle	Stress (psf)	1061

	Date test conducted	2/8/2018
	Centrifuge used	3
	Cup Number	2
	Conducted by	Karly
SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	236.91	gravity
	Initial Moisture Content	24.0%	25.1%	%
	Mass Soil Added	38.03	37.91	g
	Dry Unit Weight	15.05	15.28	kN/m3
	Height of Sample	1.000	0.986	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.013	cm
	Testing Height	0.960	0.963	cm
	Void Ratio, e	0.759	0.764	-
	Moisture Content	25.1%	32.2%	%
	Saturation	90.6%	100.0%	%
	Change in Moisture Content	-	7.2%	%
	Overburden Mass	-	73.14	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.3%	%
	Ultimate Swell	-	0.3%	%

NOTES	4% HL



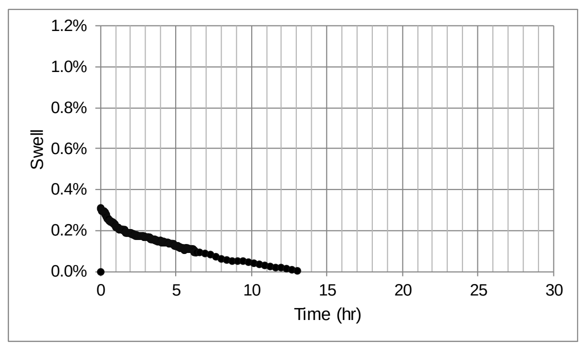
Primary Swell (%)	0.3%	Ultimate Swell (%)	0.3%
Slope of Primary Swelling	-0.04% % per log cycle	Time to Swell (hr)	1.18
Slope of Secondary Swelling	-0.16% % per log cycle	Stress (psf)	2113

	Date test conducted	2/8/2018
	Centrifuge used	3
	Cup Number	4
	Conducted by	Karly
SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	250.00	236.91	gravity
	Initial Moisture Content	24.0%	25.1%	%
	Mass Soil Added	38.02	37.94	g
	Dry Unit Weight	15.00	14.98	kN/m3
	Height of Sample	1.000	0.990	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.002	cm
	Testing Height	0.980	0.983	cm
	Void Ratio, e	0.794	0.799	-
	Moisture Content	25.1%	32.0%	%
	Saturation	86.6%	100.0%	%
	Change in Moisture Content	-	7.0%	%
	Overburden Mass	-	75.25	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.3%	%
	Ultimate Swell	-	0.3%	%

NOTES	4% HL



Primary Swell (%)	0.3%	Ultimate Swell (%)	0.3%
Slope of Primary Swelling	0.66% % per log cycle	Time to Swell (hr)	0.14
Slope of Secondary Swelling	-0.16% % per log cycle	Stress (psf)	2164

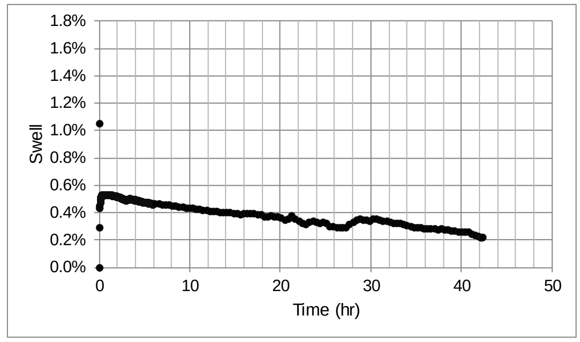
Date test conducted	4/11/2018
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	25.00	34.42	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	38.04	37.91	g
	Dry Unit Weight	14.86	14.97	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.019	cm
	Testing Height	0.985	0.991	cm
	Void Ratio, e	0.795	0.805	-
	Moisture Content	24.4%	33.3%	%
	Saturation	84.0%	100.0%	%
	Change in Moisture Content	-	8.9%	%
	Overburden Mass	-	73.73	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.5%	%

NOTES	4% HL



Primary Swell (%)	0.5%	
Slope of Primary Swelling	0.21%	% per log cycle
Slope of Secondary Swelling	-0.17%	% per log cycle

Ultimate Swell (%)	0.5%
Time to Swell (hr)	0.62
Stress (psf)	310

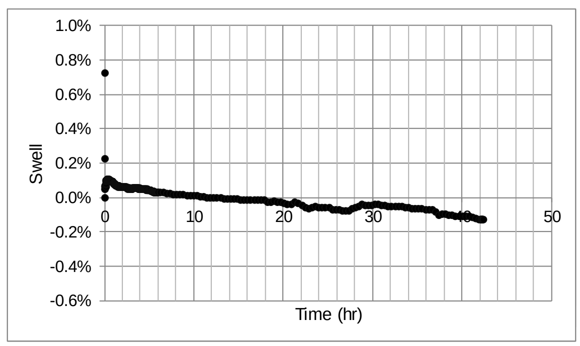
Date test conducted	4/11/2018
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	25.00	34.42	gravity
	Initial Moisture Content	24.0%	24.3%	%
	Mass Soil Added	38.04	37.95	g
	Dry Unit Weight	14.89	14.96	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.012	cm
	Testing Height	0.988	0.989	cm
	Void Ratio, e	0.797	0.799	-
	Moisture Content	24.3%	33.4%	%
	Saturation	83.5%	100.0%	%
	Change in Moisture Content	-	9.1%	%
	Overburden Mass	-	73.14	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.1%	%
	Ultimate Swell	-	0.1%	%

NOTES	4% HL



Primary Swell (%)	0.1%	
Slope of Primary Swelling	0.18%	% per log cycle
Slope of Secondary Swelling	-0.11%	% per log cycle

Ultimate Swell (%)	0.1%
Time to Swell (hr)	0.41
Stress (psf)	308

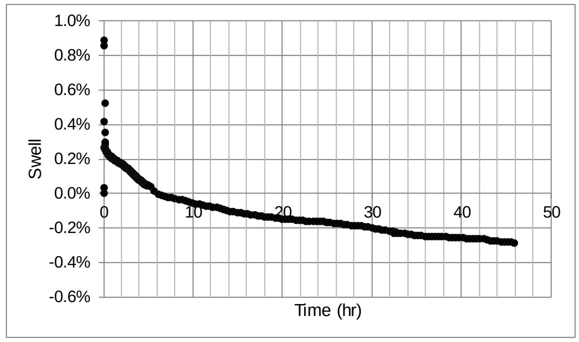
Date test conducted	11/3/2017
Centrifuge used	1
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	100.00	101.81	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	38.00	37.92	g
	Dry Unit Weight	14.83	15.14	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.055	cm
	Testing Height	0.982	0.994	cm
	Void Ratio, e	0.776	0.797	-
	Moisture Content	23.4%	31.7%	%
	Saturation	82.8%	100.0%	%
	Change in Moisture Content	-	8.3%	%
	Overburden Mass	-	40.59	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	1.2%	%

NOTES	4% HL



Primary Swell (%)	0.2%		Ultimate Swell (%)	1.2%
Slope of Primary Swelling	0.28%	% per log cycle	Time to Swell (hr)	0.44
Slope of Secondary Swelling	-0.34%	% per log cycle	Stress (psf)	585

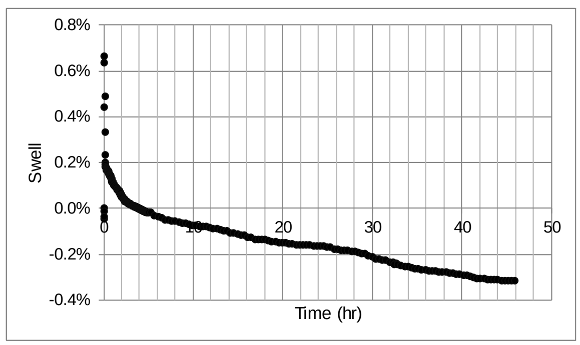
Date test conducted	11/3/2017
Centrifuge used	1
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	100.00	101.81	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.03	37.94	g
	Dry Unit Weight	14.92	15.11	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.072	cm
	Testing Height	0.984	0.991	cm
	Void Ratio, e	0.779	0.790	-
	Moisture Content	23.5%	31.1%	%
	Saturation	82.6%	100.0%	%
	Change in Moisture Content	-	7.6%	%
	Overburden Mass	-	72.54	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.7%	%

NOTES	4% HL



Primary Swell (%)	0.2%		Ultimate Swell (%)	0.7%
Slope of Primary Swelling	0.26%	% per log cycle	Time to Swell (hr)	0.21
Slope of Secondary Swelling	-0.20%	% per log cycle	Stress (psf)	904

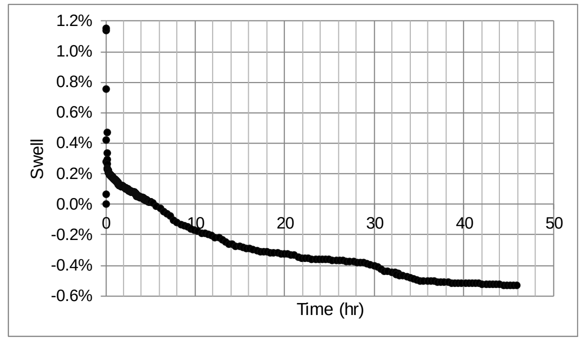
Date test conducted	11/3/2017
Centrifuge used	1
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	100.00	101.81	gravity
	Initial Moisture Content	24.0%	23.2%	%
	Mass Soil Added	38.05	37.98	g
	Dry Unit Weight	14.84	15.09	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.083	cm
	Testing Height	0.989	1.000	cm
	Void Ratio, e	0.781	0.802	-
	Moisture Content	23.2%	30.6%	%
	Saturation	81.4%	100.0%	%
	Change in Moisture Content	-	7.4%	%
	Overburden Mass	-	141.51	g
	Height of Water	2.33	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	1.2%	%

NOTES	4% HL



Primary Swell (%)	0.2%	
Slope of Primary Swelling	0.24%	% per log cycle
Slope of Secondary Swelling	-0.49%	% per log cycle

Ultimate Swell (%)	1.2%
Time to Swell (hr)	0.62
Stress (psf)	1585

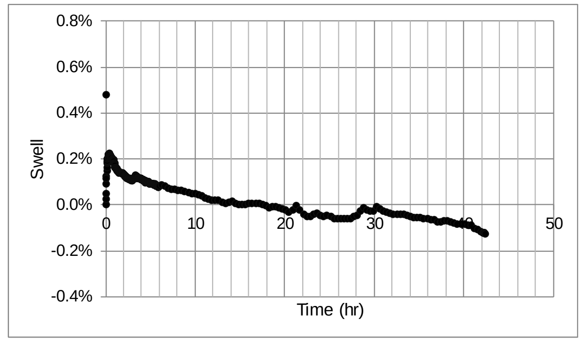
Date test conducted	4/11/2018
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	25.00	34.42	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	38.06	37.95	g
	Dry Unit Weight	14.84	14.89	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.005	cm
	Testing Height	0.994	0.997	cm
	Void Ratio, e	0.806	0.810	-
	Moisture Content	24.1%	32.9%	%
	Saturation	82.0%	100.0%	%
	Change in Moisture Content	-	8.8%	%
	Overburden Mass	-	75.17	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	5% HL



Primary Swell (%)	0.2%	
Ultimate Swell (%)	0.2%	
Slope of Primary Swelling	0.30%	% per log cycle
Time to Swell (hr)	0.38	
Slope of Secondary Swelling	-0.17%	% per log cycle
Stress (psf)	315	

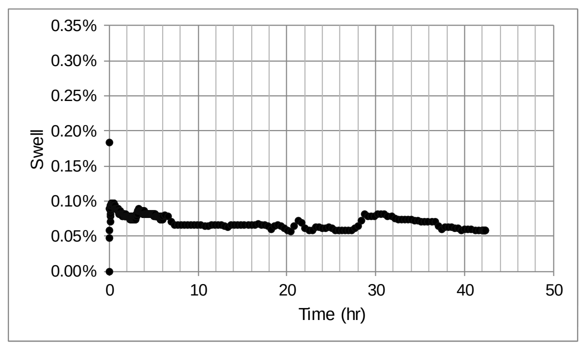
Date test conducted	4/11/2018
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	25.00	34.42	gravity
	Initial Moisture Content	24.0%	24.3%	%
	Mass Soil Added	38.06	37.99	g
	Dry Unit Weight	14.90	14.88	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.001	cm
	Testing Height	0.994	0.995	cm
	Void Ratio, e	0.806	0.808	-
	Moisture Content	24.3%	33.2%	%
	Saturation	82.6%	100.0%	%
	Change in Moisture Content	-	8.9%	%
	Overburden Mass	-	73.52	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.1%	%
	Ultimate Swell	-	0.1%	%

NOTES	5% HL



Primary Swell (%)	0.1%	
Ultimate Swell (%)	0.1%	
Slope of Primary Swelling	0.08%	% per log cycle
Time to Swell (hr)	0.28	
Slope of Secondary Swelling	-0.03%	% per log cycle
Stress (psf)	309	

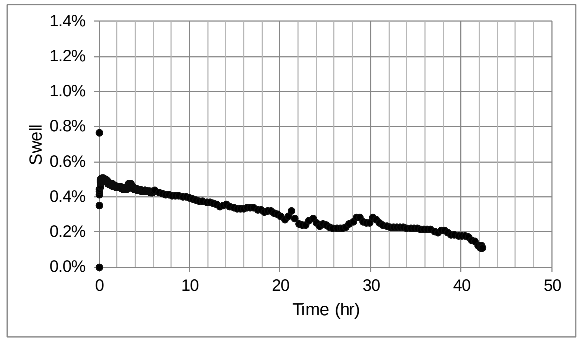
Date test conducted	4/11/2018
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	25.00	34.42	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	38.07	38.02	g
	Dry Unit Weight	14.92	14.98	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.007	cm
	Testing Height	0.986	0.991	cm
	Void Ratio, e	0.794	0.803	-
	Moisture Content	24.6%	34.3%	%
	Saturation	84.9%	100.0%	%
	Change in Moisture Content	-	9.7%	%
	Overburden Mass	-	74.19	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.5%	%

NOTES	6% HL



Primary Swell (%)	0.5%	Ultimate Swell (%)	0.5%
Slope of Primary Swelling	0.14% % per log cycle	Time to Swell (hr)	0.76
Slope of Secondary Swelling	-0.21% % per log cycle	Stress (psf)	311

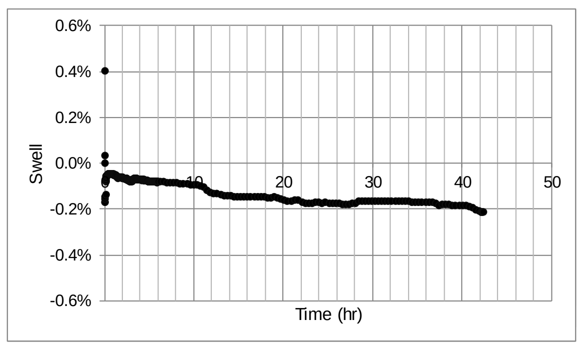
Date test conducted	4/11/2018
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	25.00	34.42	gravity
	Initial Moisture Content	24.0%	24.7%	%
	Mass Soil Added	38.07	38.02	g
	Dry Unit Weight	14.88	14.89	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.011	cm
	Testing Height	0.991	0.991	cm
	Void Ratio, e	0.805	0.804	-
	Moisture Content	24.7%	33.1%	%
	Saturation	84.0%	100.0%	%
	Change in Moisture Content	-	8.4%	%
	Overburden Mass	-	73.66	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.0%	%
	Ultimate Swell	-	0.0%	%

NOTES	6% HL



Primary Swell (%)	0.0%	Ultimate Swell (%)	0.0%
Slope of Primary Swelling	0.20% % per log cycle	Time to Swell (hr)	0.45
Slope of Secondary Swelling	-0.11% % per log cycle	Stress (psf)	309

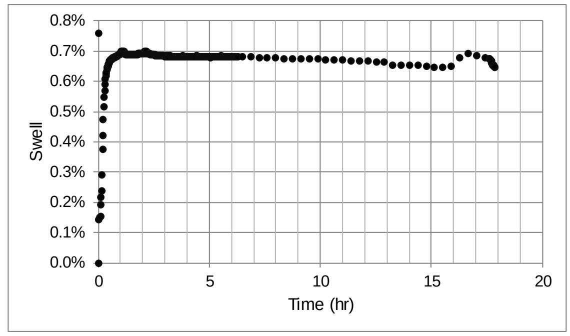
Date test conducted	6/28/2017	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.57	gravity
	Initial Moisture Content	24.0%	25.9%	%
	Mass Soil Added	37.91	37.83	g
	Dry Unit Weight	15.03	14.79	kN/m3
	Height of Sample	1.000	0.985	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.129	cm
	Testing Height	0.984	0.990	cm
	Void Ratio, e	0.818	0.830	-
	Moisture Content	25.9%	34.1%	%
	Saturation	86.7%	100.0%	%
	Change in Moisture Content	-	8.2%	%
	Overburden Mass	-	40.87	g
	Height of Water	2.26	-	cm
	Primary Swell	-	0.6%	%
	Ultimate Swell	-	0.7%	%

NOTES	6% HL



Primary Swell (%)	0.6%		Ultimate Swell (%)	0.7%
Slope of Primary Swelling	1.10%	% per log cycle	Time to Swell (hr)	0.38
Slope of Secondary Swelling	-0.04%	% per log cycle	Stress (psf)	142

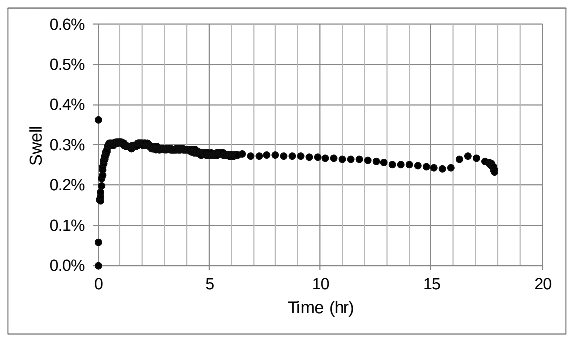
Date test conducted	6/28/2017	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.57	gravity
	Initial Moisture Content	24.0%	25.2%	%
	Mass Soil Added	37.90	37.84	g
	Dry Unit Weight	14.82	14.66	kN/m3
	Height of Sample	1.000	0.998	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.145	cm
	Testing Height	0.998	1.001	cm
	Void Ratio, e	0.834	0.839	-
	Moisture Content	25.2%	33.8%	%
	Saturation	82.9%	100.0%	%
	Change in Moisture Content	-	8.6%	%
	Overburden Mass	-	39.44	g
	Height of Water	2.24	-	cm
	Primary Swell	-	0.3%	%
	Ultimate Swell	-	0.3%	%

NOTES	6% HL



Primary Swell (%)	0.3%		Ultimate Swell (%)	0.3%
Slope of Primary Swelling	0.26%	% per log cycle	Time to Swell (hr)	0.53
Slope of Secondary Swelling	-0.06%	% per log cycle	Stress (psf)	139

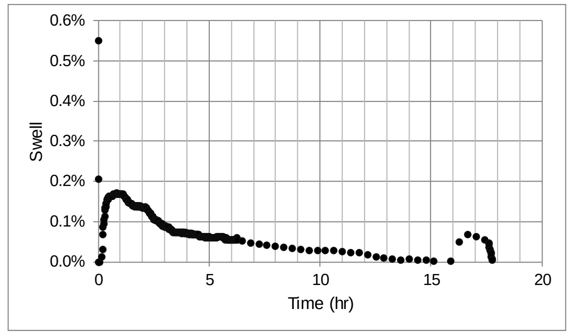
Date test conducted	6/28/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	30.00	24.57	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	37.90	37.79	g
	Dry Unit Weight	14.89	14.74	kN/m3
	Height of Sample	1.000	0.994	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	-0.094	cm
	Testing Height	0.993	0.994	cm
	Void Ratio, e	0.824	0.827	-
	Moisture Content	25.0%	34.0%	%
	Saturation	83.3%	100.0%	%
	Change in Moisture Content	-	8.9%	%
	Overburden Mass	-	72.50	g
	Height of Water	2.25	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	6% HL



Primary Swell (%)	**0.2%**	
Slope of Primary Swelling	0.39%	% per log cycle
Slope of Secondary Swelling	-0.10%	% per log cycle

Ultimate Swell (%)	**0.2%**
Time to Swell (hr)	**0.40**
Stress (psf)	**218**

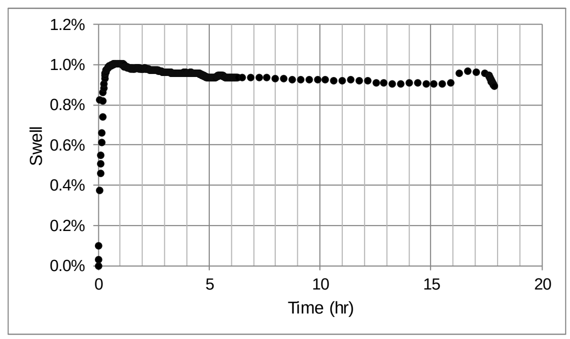
Date test conducted	6/28/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	30.00	24.57	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	37.91	37.77	g
	Dry Unit Weight	14.79	14.62	kN/m3
	Height of Sample	1.000	1.001	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	-0.073	cm
	Testing Height	1.000	1.010	cm
	Void Ratio, e	0.838	0.857	-
	Moisture Content	25.0%	33.9%	%
	Saturation	81.7%	100.0%	%
	Change in Moisture Content	-	8.9%	%
	Overburden Mass	-	74.07	g
	Height of Water	2.23	-	cm
	Primary Swell	-	1.0%	%
	Ultimate Swell	-	1.0%	%

NOTES	6% HL



Primary Swell (%)	**1.0%**	
Slope of Primary Swelling	1.18%	% per log cycle
Slope of Secondary Swelling	-0.06%	% per log cycle

Ultimate Swell (%)	**1.0%**
Time to Swell (hr)	**0.34**
Stress (psf)	**222**

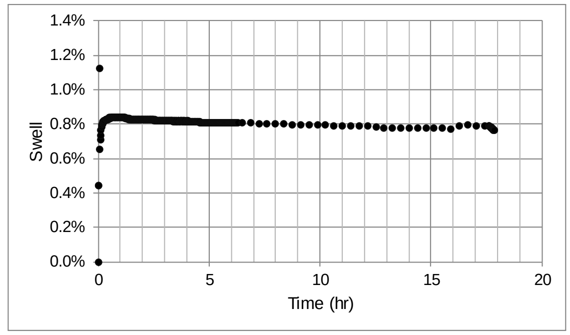
	Date test conducted	6/28/2017
	Centrifuge used	3
	Cup Number	5
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.57	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	37.20	37.20	g
	Dry Unit Weight	14.58	14.48	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.113	cm
	Testing Height	0.995	1.004	cm
	Void Ratio, e	0.857	0.872	-
	Moisture Content	25.0%	34.9%	%
	Saturation	79.8%	100.0%	%
	Change in Moisture Content	-	10.0%	%
	Overburden Mass	-	139.99	g
	Height of Water	2.22	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	6% HL



Primary Swell (%)	0.8%		Ultimate Swell (%)	0.8%
Slope of Primary Swelling	0.40%	% per log cycle	Time to Swell (hr)	0.28
Slope of Secondary Swelling	-0.06%	% per log cycle	Stress (psf)	378

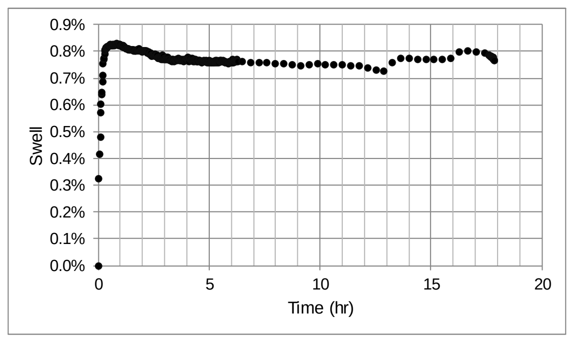
	Date test conducted	6/28/2017
	Centrifuge used	3
	Cup Number	6
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.57	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	37.29	37.16	g
	Dry Unit Weight	14.53	14.41	kN/m3
	Height of Sample	1.000	1.002	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.043	cm
	Testing Height	1.000	1.008	cm
	Void Ratio, e	0.865	0.880	-
	Moisture Content	24.8%	34.3%	%
	Saturation	78.6%	100.0%	%
	Change in Moisture Content	-	9.5%	%
	Overburden Mass	-	140.06	g
	Height of Water	2.26	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	6% HL



Primary Swell (%)	0.8%		Ultimate Swell (%)	0.8%
Slope of Primary Swelling	0.57%	% per log cycle	Time to Swell (hr)	0.36
Slope of Secondary Swelling	-0.07%	% per log cycle	Stress (psf)	379

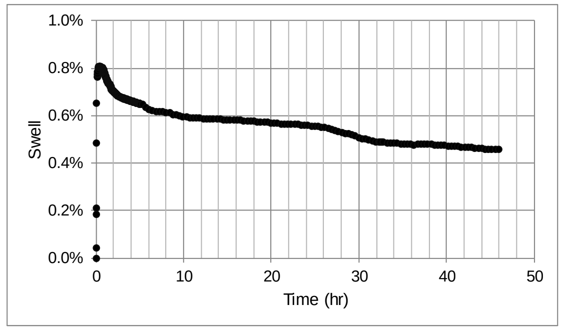
Date test conducted	11/3/2017
Centrifuge used	1
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	100.00	101.81	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.04	37.98	g
	Dry Unit Weight	14.99	15.14	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.073	cm
	Testing Height	0.982	0.990	cm
	Void Ratio, e	0.776	0.790	-
	Moisture Content	23.7%	30.8%	%
	Saturation	83.6%	100.0%	%
	Change in Moisture Content	-	7.1%	%
	Overburden Mass	-	40.13	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	6% HL



Primary Swell (%)	0.8%		Ultimate Swell (%)	0.8%
Slope of Primary Swelling	0.76%	% per log cycle	Time to Swell (hr)	0.21
Slope of Secondary Swelling	-0.13%	% per log cycle	Stress (psf)	582

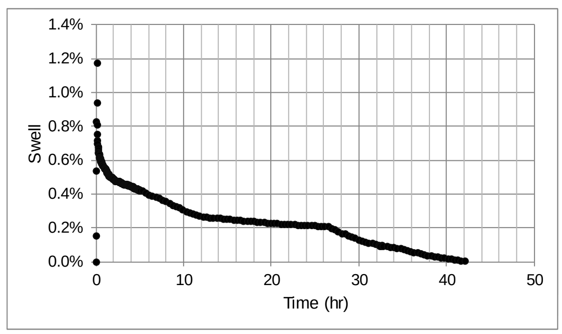
Date test conducted	11/3/2017
Centrifuge used	1
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	100.00	101.81	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	38.09	38.03	g
	Dry Unit Weight	14.83	15.12	kN/m3
	Height of Sample	1.000	1.003	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.094	cm
	Testing Height	0.985	1.000	cm
	Void Ratio, e	0.778	0.803	-
	Moisture Content	23.6%	31.2%	%
	Saturation	83.0%	100.0%	%
	Change in Moisture Content	-	7.7%	%
	Overburden Mass	-	140.44	g
	Height of Water	2.32	-	cm
	Primary Swell	-	0.7%	%
	Ultimate Swell	-	1.5%	%

NOTES	6% HL



Primary Swell (%)	0.7%		Ultimate Swell (%)	1.5%
Slope of Primary Swelling	0.62%	% per log cycle	Time to Swell (hr)	0.21
Slope of Secondary Swelling	-0.28%	% per log cycle	Stress (psf)	1575

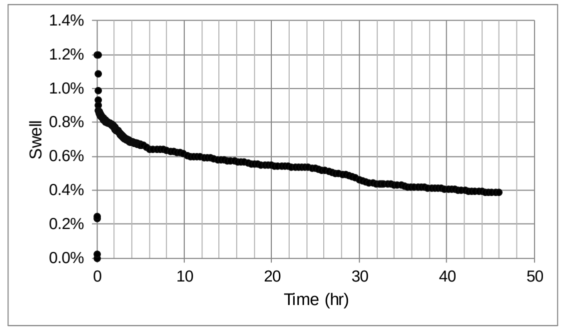
Date test conducted	11/3/2017
Centrifuge used	1
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	100.00	101.81	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	38.07	38.00	g
	Dry Unit Weight	14.91	15.04	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.124	cm
	Testing Height	0.987	0.999	cm
	Void Ratio, e	0.787	0.808	-
	Moisture Content	23.8%	31.3%	%
	Saturation	82.9%	100.0%	%
	Change in Moisture Content	-	7.5%	%
	Overburden Mass	-	73.33	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	1.2%	%

NOTES	6% HL



Primary Swell (%)	0.8%	Ultimate Swell (%)	1.2%
Slope of Primary Swelling	0.45% % per log cycle	Time to Swell (hr)	1.02
Slope of Secondary Swelling	-0.20% % per log cycle	Stress (psf)	912

APPENDIX C: CURED AND MELLOWED LIME-TREATED CENTRIFUGE TEST RESULTS

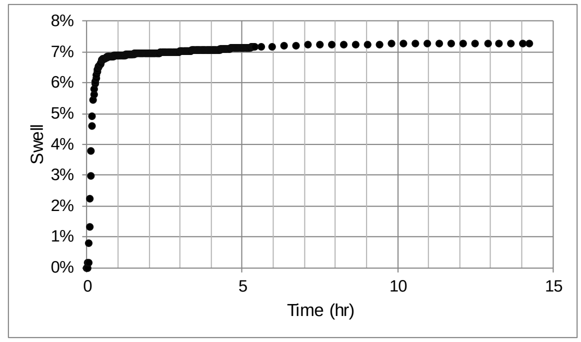
Date test conducted	7/6/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.78	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	37.94	37.81	g
	Dry Unit Weight	14.94	14.89	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.129	cm
	Testing Height	0.990	1.062	cm
	Void Ratio, e	0.805	0.936	-
	Moisture Content	24.1%	37.6%	%
	Saturation	82.0%	100.0%	%
	Change in Moisture Content	-	13.5%	%
	Overburden Mass	-	40.08	g
	Height of Water	2.27	-	cm
	Primary Swell	-	6.4%	%
	Ultimate Swell	-	7.3%	%

NOTES	
	2% HL; 1 Day Mellow



Primary Swell (%)	6.4%		Ultimate Swell (%)	7.3%	
Slope of Primary Swelling	8.76%	% per log cycle	Time to Swell (hr)	0.33	
Slope of Secondary Swelling	0.41%	% per log cycle	Stress (psf)	108	

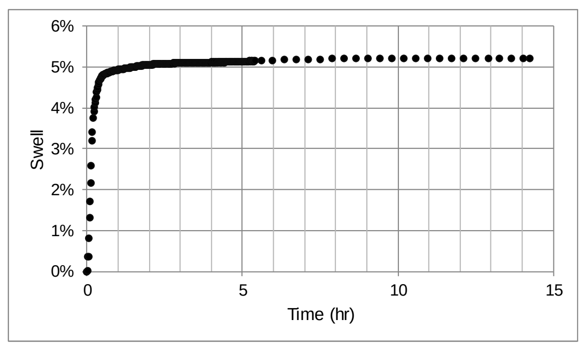
Date test conducted	7/6/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.78	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	37.96	37.83	g
	Dry Unit Weight	14.86	14.86	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.160	cm
	Testing Height	0.995	1.047	cm
	Void Ratio, e	0.808	0.903	-
	Moisture Content	23.9%	36.7%	%
	Saturation	80.9%	100.0%	%
	Change in Moisture Content	-	12.8%	%
	Overburden Mass	-	40.32	g
	Height of Water	2.21	-	cm
	Primary Swell	-	4.6%	%
	Ultimate Swell	-	5.2%	%

NOTES	
	2% HL; 1 Day Mellow



Primary Swell (%)	4.6%		Ultimate Swell (%)	5.2%
Slope of Primary Swelling	5.37%	% per log cycle	Time to Swell (hr)	0.37
Slope of Secondary Swelling	0.28%	% per log cycle	Stress (psf)	108

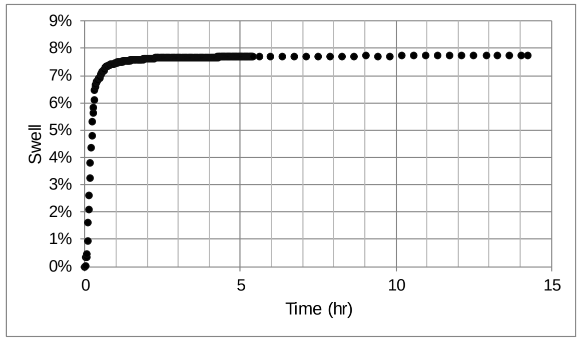
Date test conducted	7/6/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.78	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.95	37.88	g
	Dry Unit Weight	14.95	14.88	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.067	cm
	Testing Height	0.989	1.065	cm
	Void Ratio, e	0.807	0.947	-
	Moisture Content	24.6%	37.5%	%
	Saturation	83.7%	100.0%	%
	Change in Moisture Content	-	12.8%	%
	Overburden Mass	-	73.73	g
	Height of Water	2.28	-	cm
	Primary Swell	-	6.9%	%
	Ultimate Swell	-	7.7%	%

NOTES	2% HL; 1 Day Mellow



Primary Swell (%)	6.9%		Ultimate Swell (%)	7.7%
Slope of Primary Swelling	9.01%	% per log cycle	Time to Swell (hr)	0.43
Slope of Secondary Swelling	0.26%	% per log cycle	Stress (psf)	170

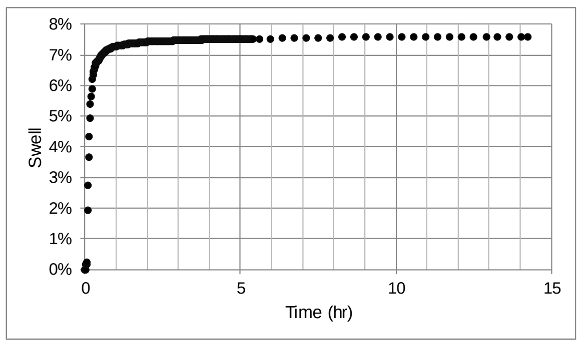
Date test conducted	7/6/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.78	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.92	37.83	g
	Dry Unit Weight	14.96	14.88	kN/m3
	Height of Sample	1.000	0.990	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.046	cm
	Testing Height	0.987	1.062	cm
	Void Ratio, e	0.806	0.943	-
	Moisture Content	24.6%	37.5%	%
	Saturation	83.6%	100.0%	%
	Change in Moisture Content	-	12.8%	%
	Overburden Mass	-	74.16	g
	Height of Water	2.28	-	cm
	Primary Swell	-	6.7%	%
	Ultimate Swell	-	7.6%	%

NOTES	2% HL; 1 Day Mellow



Primary Swell (%)	6.7%		Ultimate Swell (%)	7.6%
Slope of Primary Swelling	8.39%	% per log cycle	Time to Swell (hr)	0.35
Slope of Secondary Swelling	0.29%	% per log cycle	Stress (psf)	170

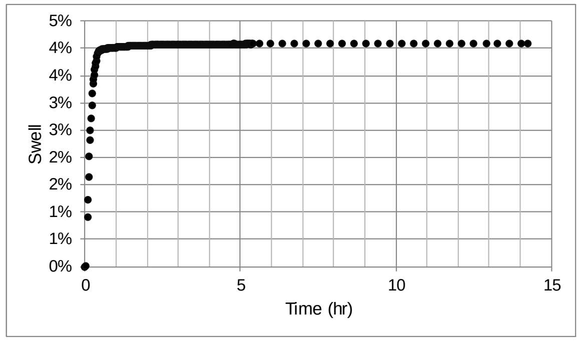
Date test conducted	7/6/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.78	gravity
	Initial Moisture Content	24.0%	24.2%	%
	Mass Soil Added	37.97	37.92	g
	Dry Unit Weight	14.94	14.90	kN/m3
	Height of Sample	1.000	0.992	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.066	cm
	Testing Height	0.992	1.033	cm
	Void Ratio, e	0.804	0.878	-
	Moisture Content	24.2%	34.9%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	10.7%	%
	Overburden Mass	-	142.87	g
	Height of Water	2.30	-	cm
	Primary Swell	-	3.8%	%
	Ultimate Swell	-	4.1%	%

NOTES	2% HL; 1 Day Mellow



Primary Swell (%)	3.8%		Ultimate Swell (%)	4.1%
Slope of Primary Swelling	4.70%	% per log cycle	Time to Swell (hr)	0.37
Slope of Secondary Swelling	0.07%	% per log cycle	Stress (psf)	295

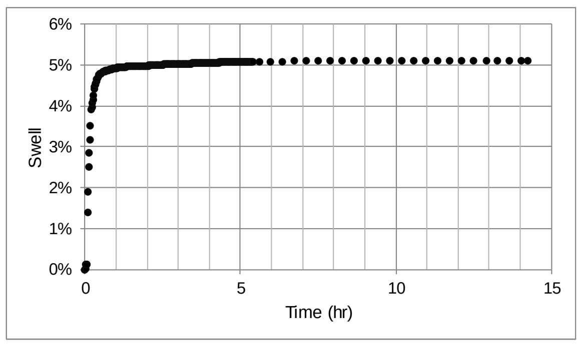
Date test conducted	7/6/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.78	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	37.94	37.90	g
	Dry Unit Weight	14.84	14.73	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.106	cm
	Testing Height	0.997	1.048	cm
	Void Ratio, e	0.825	0.918	-
	Moisture Content	24.9%	37.4%	%
	Saturation	82.7%	100.0%	%
	Change in Moisture Content	-	12.6%	%
	Overburden Mass	-	141.07	g
	Height of Water	2.31	-	cm
	Primary Swell	-	4.6%	%
	Ultimate Swell	-	5.1%	%

NOTES	2% HL; 1 Day Mellow



Primary Swell (%)	4.6%		Ultimate Swell (%)	5.1%
Slope of Primary Swelling	5.33%	% per log cycle	Time to Swell (hr)	0.35
Slope of Secondary Swelling	0.20%	% per log cycle	Stress (psf)	292

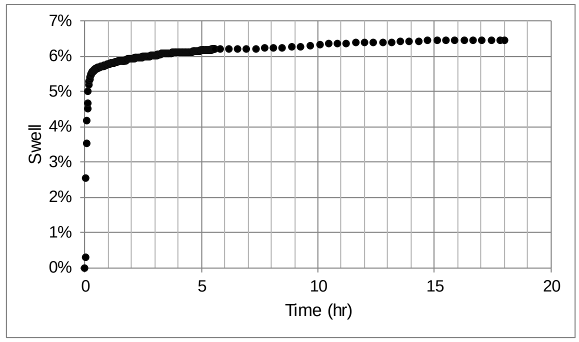
Date test conducted	7/17/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.21	gravity
	Initial Moisture Content	24.0%	23.8%	%
	Mass Soil Added	37.96	37.69	g
	Dry Unit Weight	14.80	14.77	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.065	cm
	Testing Height	0.998	1.062	cm
	Void Ratio, e	0.820	0.937	-
	Moisture Content	23.8%	37.3%	%
	Saturation	79.5%	100.0%	%
	Change in Moisture Content	-	13.5%	%
	Overburden Mass	-	39.95	g
	Height of Water	2.30	-	cm
	Primary Swell	-	5.2%	%
	Ultimate Swell	-	6.5%	%

NOTES	2% HL; 28 Day Mellow



Primary Swell (%)	5.2%	
Slope of Primary Swelling	4.86%	% per log cycle
Slope of Secondary Swelling	0.58%	% per log cycle

Ultimate Swell (%)	6.5%
Time to Swell (hr)	0.16
Stress (psf)	127

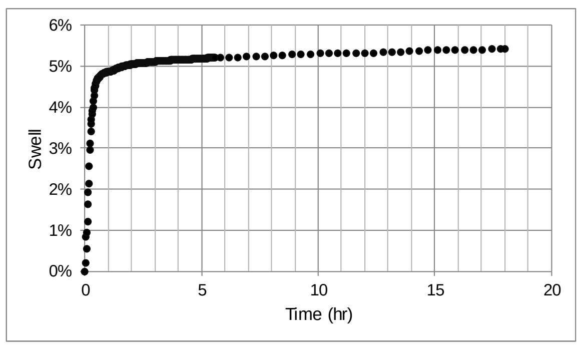
Date test conducted	7/17/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.21	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	37.95	37.79	g
	Dry Unit Weight	14.84	14.85	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.101	cm
	Testing Height	0.996	1.050	cm
	Void Ratio, e	0.810	0.908	-
	Moisture Content	23.7%	37.3%	%
	Saturation	80.2%	100.0%	%
	Change in Moisture Content	-	13.6%	%
	Overburden Mass	-	40.19	g
	Height of Water	2.32	-	cm
	Primary Swell	-	4.6%	%
	Ultimate Swell	-	5.4%	%

NOTES	2% HL; 28 Day Mellow



Primary Swell (%)	4.6%	
Slope of Primary Swelling	5.50%	% per log cycle
Slope of Secondary Swelling	0.40%	% per log cycle

Ultimate Swell (%)	5.4%
Time to Swell (hr)	0.46
Stress (psf)	128

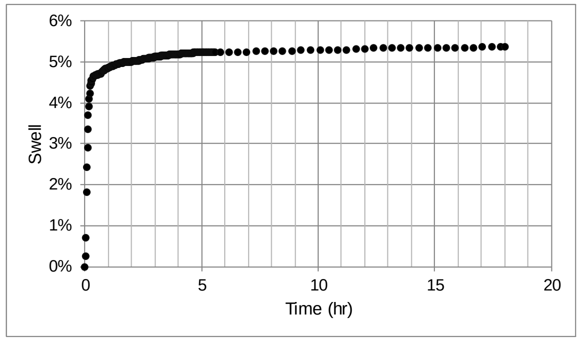
Date test conducted	7/17/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.21	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	37.96	37.68	g
	Dry Unit Weight	14.94	14.93	kN/m3
	Height of Sample	1.000	0.992	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.010	cm
	Testing Height	0.989	1.042	cm
	Void Ratio, e	0.800	0.897	-
	Moisture Content	23.5%	37.0%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	13.5%	%
	Overburden Mass	-	73.62	g
	Height of Water	2.31	-	cm
	Primary Swell	-	4.5%	%
	Ultimate Swell	-	5.4%	%

NOTES	2% HL; 28 Day Mellow



Primary Swell (%)	4.5%	Ultimate Swell (%)	5.4%
Slope of Primary Swelling	4.64% % per log cycle	Time to Swell (hr)	0.26
Slope of Secondary Swelling	0.38% % per log cycle	Stress (psf)	200

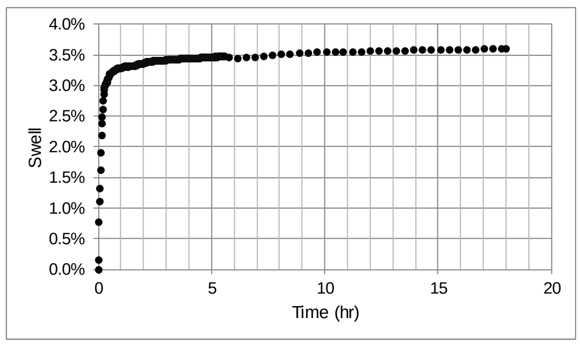
Date test conducted	7/17/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.21	gravity
	Initial Moisture Content	24.0%	24.2%	%
	Mass Soil Added	37.97	37.79	g
	Dry Unit Weight	14.85	14.79	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.110	cm
	Testing Height	0.996	1.032	cm
	Void Ratio, e	0.817	0.883	-
	Moisture Content	24.2%	36.6%	%
	Saturation	81.1%	100.0%	%
	Change in Moisture Content	-	12.5%	%
	Overburden Mass	-	73.74	g
	Height of Water	2.31	-	cm
	Primary Swell	-	3.0%	%
	Ultimate Swell	-	3.6%	%

NOTES	2% HL; 28 Day Mellow



Primary Swell (%)	3.0%	Ultimate Swell (%)	3.6%
Slope of Primary Swelling	2.88% % per log cycle	Time to Swell (hr)	0.32
Slope of Secondary Swelling	0.27% % per log cycle	Stress (psf)	200

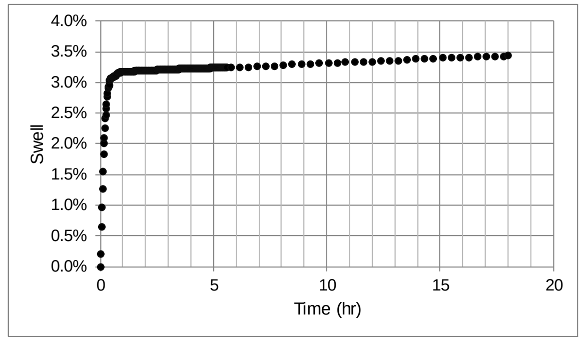
Date test conducted	7/17/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	22.21	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.94	37.91	g
	Dry Unit Weight	14.89	14.84	kN/m3
	Height of Sample	1.000	0.995	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.091	cm
	Testing Height	0.993	1.027	cm
	Void Ratio, e	0.812	0.874	-
	Moisture Content	24.6%	36.7%	%
	Saturation	83.0%	100.0%	%
	Change in Moisture Content	-	12.1%	%
	Overburden Mass	-	141.04	g
	Height of Water	2.31	-	cm
	Primary Swell	-	3.0%	%
	Ultimate Swell	-	3.4%	%

NOTES	2% HL; 28 Day Mellow



Primary Swell (%)	3.0%		Ultimate Swell (%)	3.4%
Slope of Primary Swelling	3.08%	% per log cycle	Time to Swell (hr)	0.38
Slope of Secondary Swelling	0.17%	% per log cycle	Stress (psf)	345

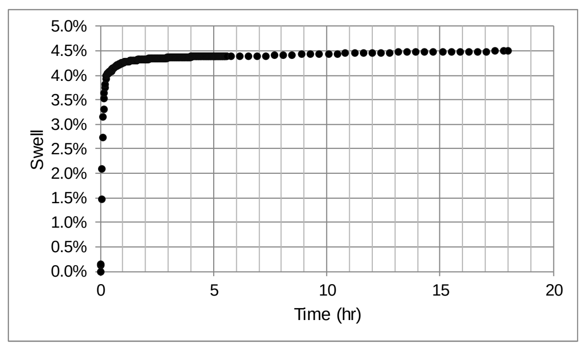
Date test conducted	7/17/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	22.21	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	37.96	37.93	g
	Dry Unit Weight	14.87	14.87	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.057	cm
	Testing Height	0.996	1.041	cm
	Void Ratio, e	0.807	0.889	-
	Moisture Content	24.0%	36.2%	%
	Saturation	81.3%	100.0%	%
	Change in Moisture Content	-	12.2%	%
	Overburden Mass	-	140.59	g
	Height of Water	2.26	-	cm
	Primary Swell	-	4.0%	%
	Ultimate Swell	-	4.5%	%

NOTES	2% HL; 28 Day Mellow



Primary Swell (%)	4.0%		Ultimate Swell (%)	4.5%
Slope of Primary Swelling	4.34%	% per log cycle	Time to Swell (hr)	0.26
Slope of Secondary Swelling	0.17%	% per log cycle	Stress (psf)	344

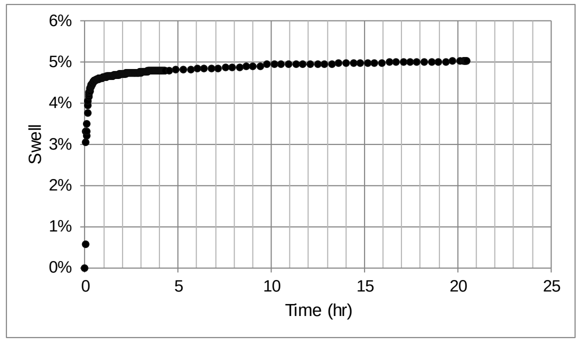
Date test conducted	7/25/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.14	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.62	37.46	g
	Dry Unit Weight	14.76	14.83	kN/m3
	Height of Sample	1.000	0.995	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.012	cm
	Testing Height	0.981	1.030	cm
	Void Ratio, e	0.812	0.903	-
	Moisture Content	24.6%	39.2%	%
	Saturation	82.9%	100.0%	%
	Change in Moisture Content	-	14.7%	%
	Overburden Mass	-	40.67	g
	Height of Water	2.31	-	cm
	Primary Swell	-	4.3%	%
	Ultimate Swell	-	5.0%	%

NOTES	2% HL; 43 Day Mellow



Primary Swell (%)	4.3%	
Slope of Primary Swelling	3.58%	% per log cycle
Slope of Secondary Swelling	0.30%	% per log cycle

Ultimate Swell (%)	5.0%
Time to Swell (hr)	0.25
Stress (psf)	116

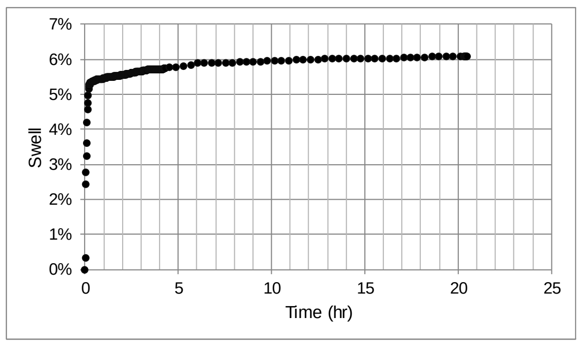
Date test conducted	7/25/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.14	gravity
	Initial Moisture Content	24.0%	24.7%	%
	Mass Soil Added	37.66	37.55	g
	Dry Unit Weight	14.76	14.78	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.039	cm
	Testing Height	0.986	1.046	cm
	Void Ratio, e	0.819	0.929	-
	Moisture Content	24.7%	39.1%	%
	Saturation	82.6%	100.0%	%
	Change in Moisture Content	-	14.4%	%
	Overburden Mass	-	39.49	g
	Height of Water	2.27	-	cm
	Primary Swell	-	5.2%	%
	Ultimate Swell	-	6.1%	%

NOTES	2% HL; 43 Day Mellow



Primary Swell (%)	5.2%	
Slope of Primary Swelling	4.86%	% per log cycle
Slope of Secondary Swelling	0.50%	% per log cycle

Ultimate Swell (%)	6.1%
Time to Swell (hr)	0.19
Stress (psf)	114

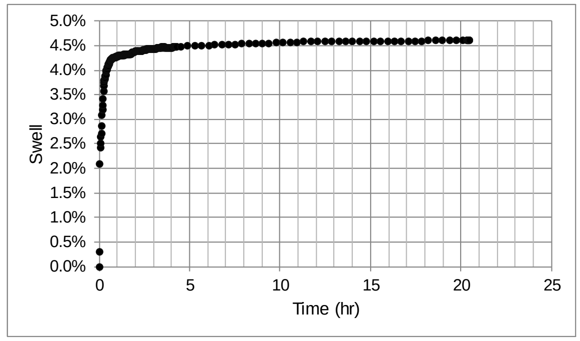
Date test conducted	7/25/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	20.14	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.63	37.49	g
	Dry Unit Weight	14.70	14.63	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.029	cm
	Testing Height	0.995	1.041	cm
	Void Ratio, e	0.837	0.922	-
	Moisture Content	24.6%	38.3%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	13.7%	%
	Overburden Mass	-	73.71	g
	Height of Water	2.26	-	cm
	Primary Swell	-	4.0%	%
	Ultimate Swell	-	4.6%	%

NOTES	2% HL; 43 Day Mellow



Primary Swell (%)	4.0%		Ultimate Swell (%)	4.6%
Slope of Primary Swelling	2.99%	% per log cycle	Time to Swell (hr)	0.39
Slope of Secondary Swelling	0.26%	% per log cycle	Stress (psf)	181

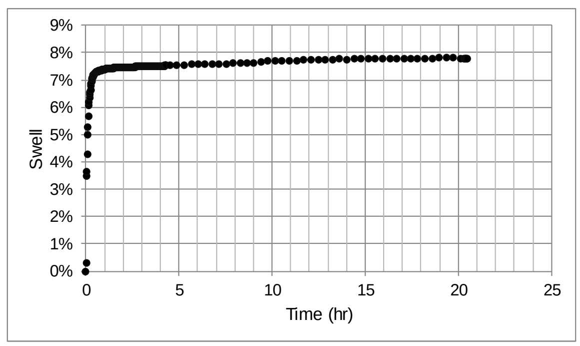
Date test conducted	7/25/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	20.14	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	36.63	36.53	g
	Dry Unit Weight	14.38	14.39	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.051	cm
	Testing Height	0.985	1.062	cm
	Void Ratio, e	0.868	1.014	-
	Moisture Content	24.8%	40.4%	%
	Saturation	78.2%	100.0%	%
	Change in Moisture Content	-	15.6%	%
	Overburden Mass	-	73.14	g
	Height of Water	2.28	-	cm
	Primary Swell	-	6.8%	%
	Ultimate Swell	-	7.8%	%

NOTES	2% HL; 43 Day Mellow



Primary Swell (%)	6.8%		Ultimate Swell (%)	7.8%
Slope of Primary Swelling	6.06%	% per log cycle	Time to Swell (hr)	0.27
Slope of Secondary Swelling	0.32%	% per log cycle	Stress (psf)	180

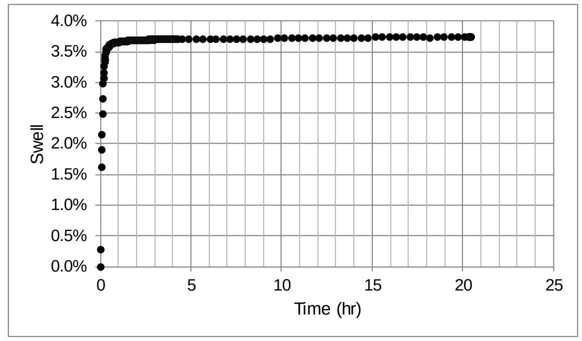
Date test conducted	7/25/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.14	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	37.64	37.54	g
	Dry Unit Weight	14.74	14.57	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.040	cm
	Testing Height	0.999	1.037	cm
	Void Ratio, e	0.845	0.914	-
	Moisture Content	24.8%	37.4%	%
	Saturation	80.3%	100.0%	%
	Change in Moisture Content	-	12.6%	%
	Overburden Mass	-	141.40	g
	Height of Water	2.28	-	cm
	Primary Swell	-	3.4%	%
	Ultimate Swell	-	3.7%	%

NOTES	2% HL; 43 Day Mellow



Primary Swell (%)	3.4%	
Slope of Primary Swelling	2.89%	% per log cycle
Slope of Secondary Swelling	0.07%	% per log cycle

Ultimate Swell (%)	3.7%
Time to Swell (hr)	0.29
Stress (psf)	313

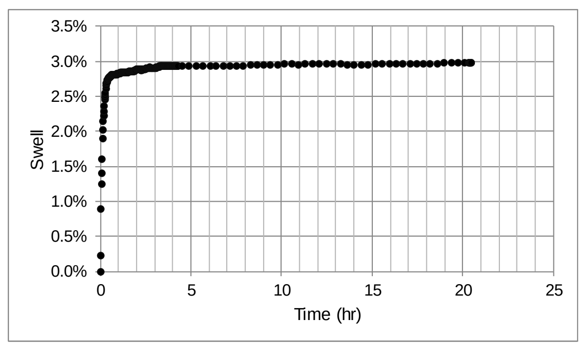
Date test conducted	7/25/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.14	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.63	37.56	g
	Dry Unit Weight	14.71	14.67	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.010	cm
	Testing Height	0.995	1.024	cm
	Void Ratio, e	0.832	0.887	-
	Moisture Content	24.6%	37.1%	%
	Saturation	80.9%	100.0%	%
	Change in Moisture Content	-	12.6%	%
	Overburden Mass	-	140.55	g
	Height of Water	2.30	-	cm
	Primary Swell	-	2.7%	%
	Ultimate Swell	-	3.0%	%

NOTES	2% HL; 43 Day Mellow



Primary Swell (%)	2.7%	
Slope of Primary Swelling	2.07%	% per log cycle
Slope of Secondary Swelling	0.11%	% per log cycle

Ultimate Swell (%)	3.0%
Time to Swell (hr)	0.35
Stress (psf)	312

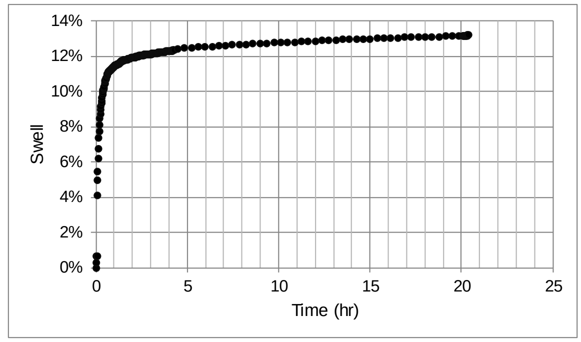
	Date test conducted	6/26/2017
	Centrifuge used	3
	Cup Number	1
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	13.29	gravity
	Initial Moisture Content	24.0%	25.1%	%
	Mass Soil Added	37.02	37.02	g
	Dry Unit Weight	14.59	14.57	kN/m3
	Height of Sample	1.000	0.990	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.161	cm
	Testing Height	0.983	1.112	cm
	Void Ratio, e	0.844	1.088	-
	Moisture Content	25.1%	43.8%	%
	Saturation	81.5%	100.0%	%
	Change in Moisture Content	-	18.7%	%
	Overburden Mass	-	40.12	g
	Height of Water	2.31	-	cm
	Primary Swell	-	10.7%	%
	Ultimate Swell	-	13.2%	%

NOTES	2% HL; 14 Day Cure



Primary Swell (%)	10.7%	Ultimate Swell (%)	13.2%
Slope of Primary Swelling	8.46% % per log cycle	Time to Swell (hr)	0.53
Slope of Secondary Swelling	1.25% % per log cycle	Stress (psf)	76

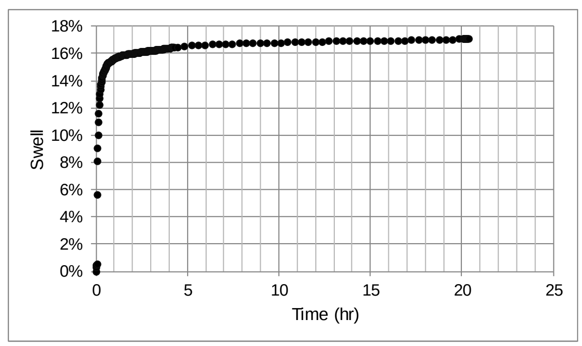
	Date test conducted	6/26/2017
	Centrifuge used	3
	Cup Number	2
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	13.29	gravity
	Initial Moisture Content	24.0%	24.5%	%
	Mass Soil Added	37.75	37.75	g
	Dry Unit Weight	14.78	14.80	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.241	cm
	Testing Height	0.991	1.160	cm
	Void Ratio, e	0.816	1.126	-
	Moisture Content	24.5%	44.8%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	20.3%	%
	Overburden Mass	-	39.42	g
	Height of Water	2.31	-	cm
	Primary Swell	-	14.7%	%
	Ultimate Swell	-	17.1%	%

NOTES	2% HL; 14 Day Cure



Primary Swell (%)	14.7%	Ultimate Swell (%)	17.1%
Slope of Primary Swelling	12.83% % per log cycle	Time to Swell (hr)	0.44
Slope of Secondary Swelling	1.04% % per log cycle	Stress (psf)	76

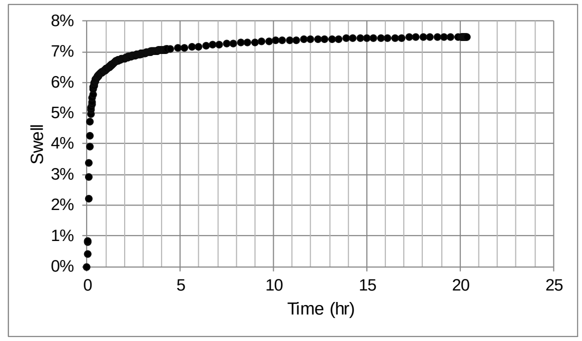
	Date test conducted	6/26/2017
	Centrifuge used	3
	Cup Number	3
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	13.29	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	36.81	36.81	g
	Dry Unit Weight	14.44	14.53	kN/m3
	Height of Sample	1.000	0.995	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.224	cm
	Testing Height	0.987	1.061	cm
	Void Ratio, e	0.850	0.988	-
	Moisture Content	24.1%	40.2%	%
	Saturation	77.9%	100.0%	%
	Change in Moisture Content	-	16.1%	%
	Overburden Mass	-	73.54	g
	Height of Water	2.31	-	cm
	Primary Swell	-	6.1%	%
	Ultimate Swell	-	7.5%	%

NOTES	2% HL; 14 Day Cure



Primary Swell (%)	6.1%	Ultimate Swell (%)	7.5%
Slope of Primary Swelling	5.43% % per log cycle	Time to Swell (hr)	0.44
Slope of Secondary Swelling	0.70% % per log cycle	Stress (psf)	119

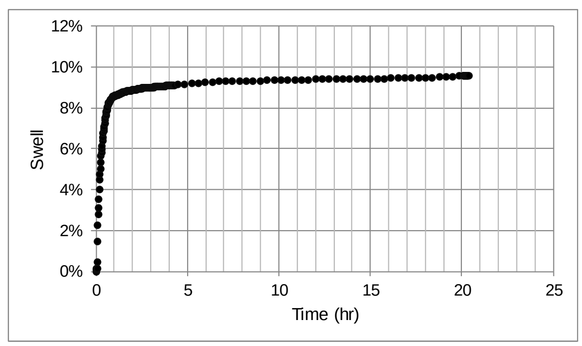
	Date test conducted	6/26/2017
	Centrifuge used	3
	Cup Number	4
	Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	13.29	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	37.59	37.59	g
	Dry Unit Weight	14.73	14.70	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.109	cm
	Testing Height	0.990	1.085	cm
	Void Ratio, e	0.829	1.003	-
	Moisture Content	25.0%	40.3%	%
	Saturation	82.6%	100.0%	%
	Change in Moisture Content	-	15.4%	%
	Overburden Mass	-	74.34	g
	Height of Water	2.32	-	cm
	Primary Swell	-	8.2%	%
	Ultimate Swell	-	9.6%	%

NOTES	2% HL; 14 Day Cure



Primary Swell (%)	8.2%	Ultimate Swell (%)	9.6%
Slope of Primary Swelling	8.45% % per log cycle	Time to Swell (hr)	0.70
Slope of Secondary Swelling	0.64% % per log cycle	Stress (psf)	121

Date test conducted	6/26/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information

Soil	EF
Target Water Content	24%
Water Content	25%
Specific Gravity	2.74

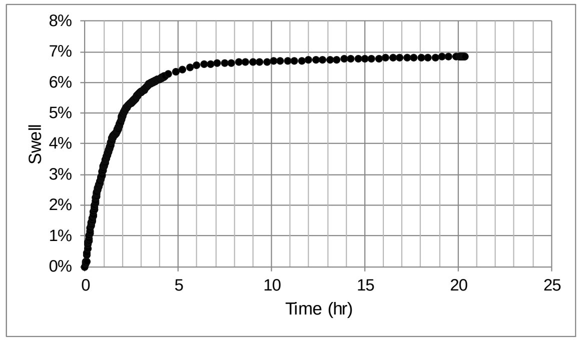
TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	20.00	13.29	gravity
Initial Moisture Content	24.0%	24.6%	%
Mass Soil Added	37.97	37.97	g
Dry Unit Weight	14.99	14.96	kN/m3
Height of Sample	1.000	0.989	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	-0.072	cm
Testing Height	0.986	1.054	cm
Void Ratio, e	0.797	0.920	-
Moisture Content	24.6%	38.2%	%
Saturation	84.5%	100.0%	%
Change in Moisture Content	-	13.6%	%
Overburden Mass	-	140.49	g
Height of Water	2.33	-	cm
Primary Swell	-	6.1%	%
Ultimate Swell	-	6.8%	%

NOTES	2% HL; 14 Day Cure



Primary Swell (%)	6.1%		Ultimate Swell (%)	6.8%
Slope of Primary Swelling	5.51%	% per log cycle	Time to Swell (hr)	3.89
Slope of Secondary Swelling	0.45%	% per log cycle	Stress (psf)	206

Date test conducted	6/26/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information

Soil	EF
Target Water Content	24%
Water Content	25%
Specific Gravity	2.74

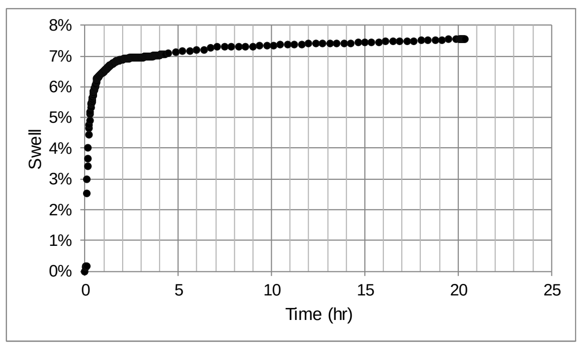
TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	20.00	13.29	gravity
Initial Moisture Content	24.0%	24.8%	%
Mass Soil Added	36.73	36.73	g
Dry Unit Weight	14.65	14.61	kN/m3
Height of Sample	1.000	0.979	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	-0.057	cm
Testing Height	0.975	1.049	cm
Void Ratio, e	0.839	0.978	-
Moisture Content	24.8%	39.4%	%
Saturation	80.8%	100.0%	%
Change in Moisture Content	-	14.6%	%
Overburden Mass	-	141.95	g
Height of Water	2.32	-	cm
Primary Swell	-	6.2%	%
Ultimate Swell	-	7.6%	%

NOTES	2% HL; 14 Day Cure



Primary Swell (%)	6.2%		Ultimate Swell (%)	7.6%
Slope of Primary Swelling	4.58%	% per log cycle	Time to Swell (hr)	0.61
Slope of Secondary Swelling	0.65%	% per log cycle	Stress (psf)	207

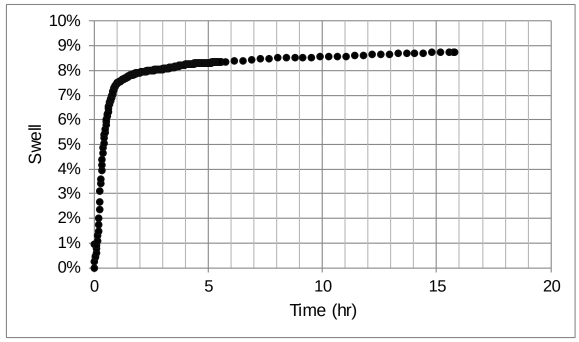
Date test conducted	7/10/2017	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	16.92	gravity
	Initial Moisture Content	24.0%	23.2%	%
	Mass Soil Added	38.28	38.28	g
	Dry Unit Weight	15.10	15.30	kN/m3
	Height of Sample	1.000	0.990	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.176	cm
	Testing Height	0.983	1.069	cm
	Void Ratio, e	0.756	0.910	-
	Moisture Content	23.2%	39.6%	%
	Saturation	83.9%	100.0%	%
	Change in Moisture Content	-	16.4%	%
	Overburden Mass	-	39.97	g
	Height of Water	2.32	-	cm
	Primary Swell	-	7.3%	%
	Ultimate Swell	-	8.7%	%

NOTES	2% HL; 21 Day Cure



Primary Swell (%)	7.3%	
Slope of Primary Swelling	9.21%	% per log cycle
Slope of Secondary Swelling	0.90%	% per log cycle
Ultimate Swell (%)	8.7%	
Time to Swell (hr)	0.88	
Stress (psf)	97	

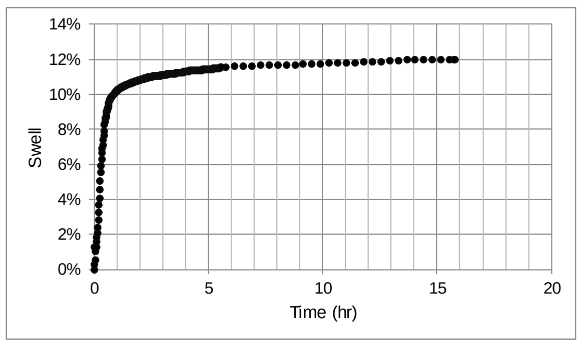
Date test conducted	7/10/2017	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	16.92	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	38.07	38.07	g
	Dry Unit Weight	14.95	15.06	kN/m3
	Height of Sample	1.000	0.994	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.097	cm
	Testing Height	0.991	1.111	cm
	Void Ratio, e	0.785	0.999	-
	Moisture Content	23.4%	41.1%	%
	Saturation	81.7%	100.0%	%
	Change in Moisture Content	-	17.7%	%
	Overburden Mass	-	40.15	g
	Height of Water	2.33	-	cm
	Primary Swell	-	9.9%	%
	Ultimate Swell	-	12.0%	%

NOTES	2% HL; 21 Day Cure



Primary Swell (%)	9.9%	
Slope of Primary Swelling	11.07%	% per log cycle
Slope of Secondary Swelling	1.25%	% per log cycle
Ultimate Swell (%)	12.0%	
Time to Swell (hr)	0.81	
Stress (psf)	98	

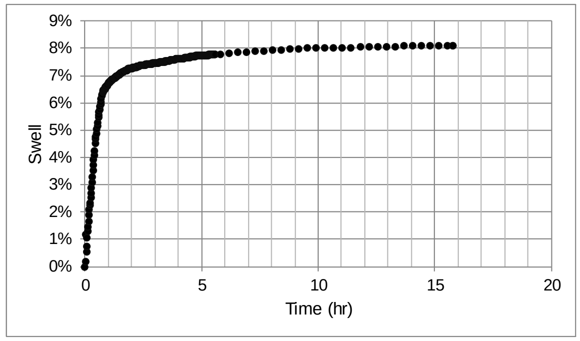
Date test conducted	7/10/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	16.92	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	38.36	38.36	g
	Dry Unit Weight	15.05	15.15	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.177	cm
	Testing Height	0.992	1.073	cm
	Void Ratio, e	0.774	0.918	-
	Moisture Content	23.5%	39.9%	%
	Saturation	83.2%	100.0%	%
	Change in Moisture Content	-	16.4%	%
	Overburden Mass	-	73.74	g
	Height of Water	2.30	-	cm
	Primary Swell	-	6.5%	%
	Ultimate Swell	-	8.1%	%

NOTES	
	2% HL; 21 Day Cure



Primary Swell (%)	6.5%	Ultimate Swell (%)	8.1%
Slope of Primary Swelling	8.48% % per log cycle	Time to Swell (hr)	0.87
Slope of Secondary Swelling	1.02% % per log cycle	Stress (psf)	153

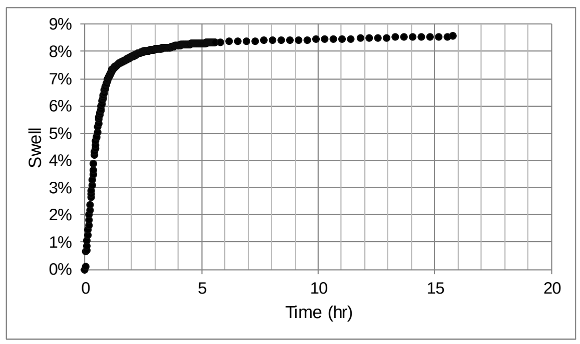
Date test conducted	7/10/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	16.92	gravity
	Initial Moisture Content	24.0%	23.1%	%
	Mass Soil Added	38.41	38.41	g
	Dry Unit Weight	15.10	15.24	kN/m3
	Height of Sample	1.000	0.993	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.187	cm
	Testing Height	0.991	1.076	cm
	Void Ratio, e	0.764	0.915	-
	Moisture Content	23.1%	38.5%	%
	Saturation	83.0%	100.0%	%
	Change in Moisture Content	-	15.4%	%
	Overburden Mass	-	73.66	g
	Height of Water	2.32	-	cm
	Primary Swell	-	7.3%	%
	Ultimate Swell	-	8.6%	%

NOTES	
	2% HL; 21 Day Cure



Primary Swell (%)	7.3%	Ultimate Swell (%)	8.6%
Slope of Primary Swelling	8.01% % per log cycle	Time to Swell (hr)	1.17
Slope of Secondary Swelling	0.73% % per log cycle	Stress (psf)	153

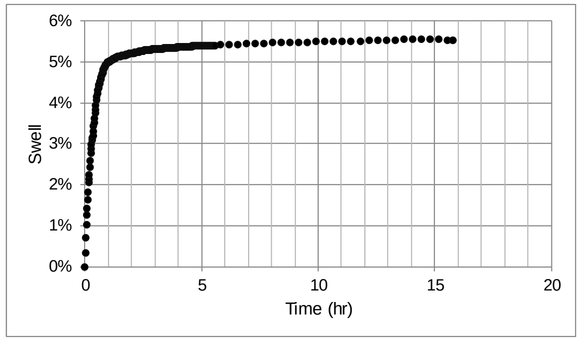
Date test conducted	7/10/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	16.92	gravity
	Initial Moisture Content	24.0%	23.0%	%
	Mass Soil Added	38.09	38.09	g
	Dry Unit Weight	14.87	15.03	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.150	cm
	Testing Height	0.997	1.053	cm
	Void Ratio, e	0.789	0.888	-
	Moisture Content	23.0%	36.4%	%
	Saturation	79.9%	100.0%	%
	Change in Moisture Content	-	13.4%	%
	Overburden Mass	-	140.45	g
	Height of Water	2.31	-	cm
	Primary Swell	-	4.9%	%
	Ultimate Swell	-	5.6%	%

NOTES	2% HL; 21 Day Cure



Primary Swell (%)	4.9%	
Slope of Primary Swelling	4.40%	% per log cycle
Slope of Secondary Swelling	0.37%	% per log cycle

Ultimate Swell (%)	5.6%
Time to Swell (hr)	0.90
Stress (psf)	262

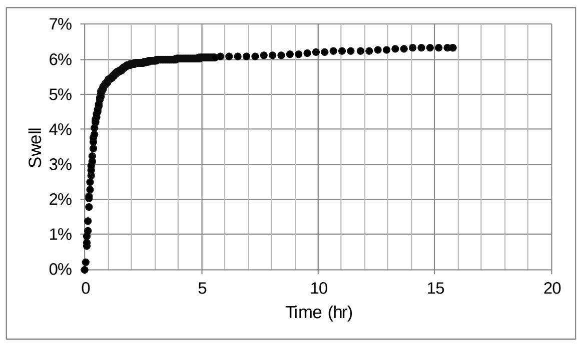
Date test conducted	7/10/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	16.92	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	38.34	38.34	g
	Dry Unit Weight	15.11	15.18	kN/m3
	Height of Sample	1.000	0.990	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.059	cm
	Testing Height	0.988	1.050	cm
	Void Ratio, e	0.770	0.882	-
	Moisture Content	23.7%	36.6%	%
	Saturation	84.4%	100.0%	%
	Change in Moisture Content	-	12.9%	%
	Overburden Mass	-	140.99	g
	Height of Water	2.32	-	cm
	Primary Swell	-	5.3%	%
	Ultimate Swell	-	6.3%	%

NOTES	2% HL; 21 Day Cure



Primary Swell (%)	5.3%	
Slope of Primary Swelling	5.46%	% per log cycle
Slope of Secondary Swelling	0.49%	% per log cycle

Ultimate Swell (%)	6.3%
Time to Swell (hr)	0.92
Stress (psf)	263

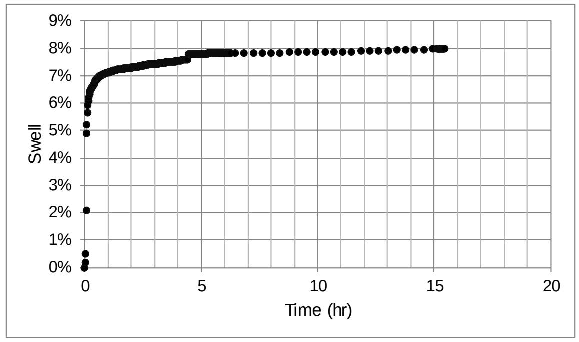
Date test conducted	8/7/2017
Centrifuge used	1
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	23.34	gravity
	Initial Moisture Content	24.0%	25.8%	%
	Mass Soil Added	36.92	36.92	g
	Dry Unit Weight	14.47	14.33	kN/m3
	Height of Sample	1.000	0.996	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-2.311	cm
	Testing Height	0.991	1.070	cm
	Void Ratio, e	0.876	1.025	-
	Moisture Content	25.8%	43.9%	%
	Saturation	80.8%	100.0%	%
	Change in Moisture Content	-	18.1%	%
	Overburden Mass	-	40.62	g
	Height of Water	2.31	-	cm
	Primary Swell	-	6.2%	%
	Ultimate Swell	-	8.0%	%

NOTES	2% HL; 56 Day Cure



Primary Swell (%)	6.2%	
Slope of Primary Swelling	9.44%	% per log cycle
Slope of Secondary Swelling	0.75%	% per log cycle

Ultimate Swell (%)	8.0%
Time to Swell (hr)	0.17
Stress (psf)	134

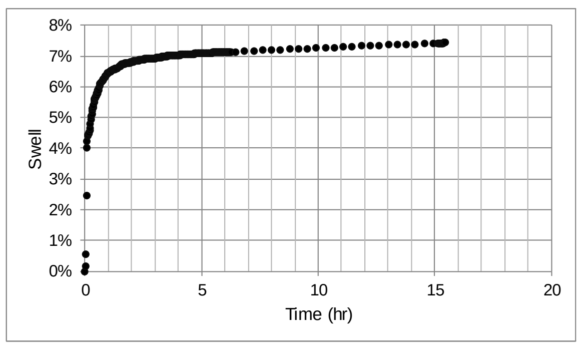
Date test conducted	8/7/2017
Centrifuge used	1
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	23.34	gravity
	Initial Moisture Content	24.0%	25.4%	%
	Mass Soil Added	36.67	36.67	g
	Dry Unit Weight	14.50	14.47	kN/m3
	Height of Sample	1.000	0.987	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.224	cm
	Testing Height	0.978	1.051	cm
	Void Ratio, e	0.857	0.995	-
	Moisture Content	25.4%	43.6%	%
	Saturation	81.2%	100.0%	%
	Change in Moisture Content	-	18.2%	%
	Overburden Mass	-	39.91	g
	Height of Water	2.30	-	cm
	Primary Swell	-	6.4%	%
	Ultimate Swell	-	7.4%	%

NOTES	2% HL; 56 Day Cure



Primary Swell (%)	6.4%	
Slope of Primary Swelling	3.35%	% per log cycle
Slope of Secondary Swelling	0.69%	% per log cycle

Ultimate Swell (%)	7.4%
Time to Swell (hr)	1.00
Stress (psf)	133

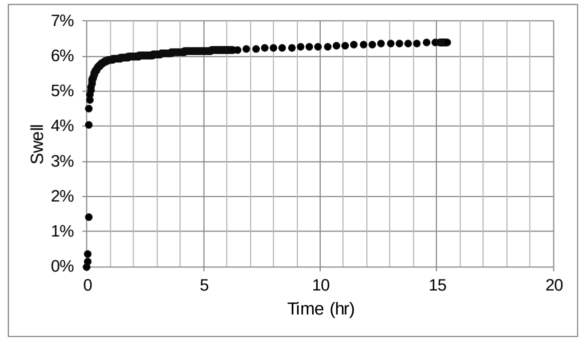
Date test conducted	8/7/2017
Centrifuge used	1
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	23.34	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	36.81	36.81	g
	Dry Unit Weight	14.35	14.39	kN/m3
	Height of Sample	1.000	1.001	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.146	cm
	Testing Height	0.991	1.054	cm
	Void Ratio, e	0.868	0.988	-
	Moisture Content	24.9%	42.1%	%
	Saturation	78.7%	100.0%	%
	Change in Moisture Content	-	17.1%	%
	Overburden Mass	-	73.53	g
	Height of Water	2.30	-	cm
	Primary Swell	-	5.2%	%
	Ultimate Swell	-	6.4%	%

NOTES	2% HL; 56 Day Cure



Primary Swell (%)	5.2%	
Slope of Primary Swelling	8.50%	% per log cycle
Slope of Secondary Swelling	0.44%	% per log cycle

Ultimate Swell (%)	6.4%
Time to Swell (hr)	0.19
Stress (psf)	209

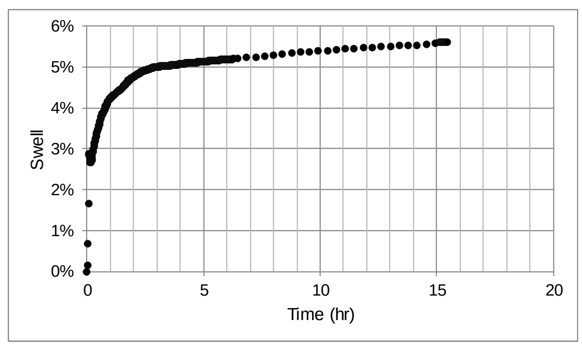
Date test conducted	8/7/2017
Centrifuge used	1
Cup Number	4
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	23.34	gravity
	Initial Moisture Content	24.0%	25.9%	%
	Mass Soil Added	37.02	37.02	g
	Dry Unit Weight	14.57	14.53	kN/m3
	Height of Sample	1.000	0.992	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.183	cm
	Testing Height	0.980	1.035	cm
	Void Ratio, e	0.850	0.954	-
	Moisture Content	25.9%	40.3%	%
	Saturation	83.4%	100.0%	%
	Change in Moisture Content	-	14.4%	%
	Overburden Mass	-	73.10	g
	Height of Water	2.33	-	cm
	Primary Swell	-	4.8%	%
	Ultimate Swell	-	5.6%	%

NOTES	2% HL; 56 Day Cure



Primary Swell (%)	4.8%	
Slope of Primary Swelling	2.07%	% per log cycle
Slope of Secondary Swelling	0.86%	% per log cycle

Ultimate Swell (%)	5.6%
Time to Swell (hr)	2.21
Stress (psf)	208

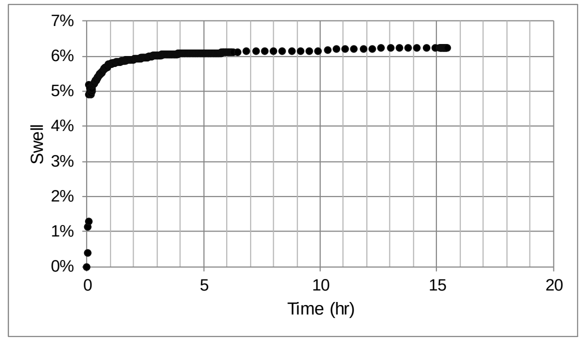
Date test conducted	8/7/2017
Centrifuge used	1
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	23.34	gravity
	Initial Moisture Content	24.0%	24.8%	%
	Mass Soil Added	36.81	36.81	g
	Dry Unit Weight	14.50	14.57	kN/m3
	Height of Sample	1.000	0.991	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.202	cm
	Testing Height	0.980	1.041	cm
	Void Ratio, e	0.845	0.960	-
	Moisture Content	24.8%	39.4%	%
	Saturation	80.5%	100.0%	%
	Change in Moisture Content	-	14.6%	%
	Overburden Mass	-	141.50	g
	Height of Water	2.28	-	cm
	Primary Swell	-	5.8%	%
	Ultimate Swell	-	6.2%	%

NOTES	2% HL; 56 Day Cure



Primary Swell (%)	5.8%	Ultimate Swell (%)	6.2%
Slope of Primary Swelling	0.94% % per log cycle	Time to Swell (hr)	1.31
Slope of Secondary Swelling	0.37% % per log cycle	Stress (psf)	363

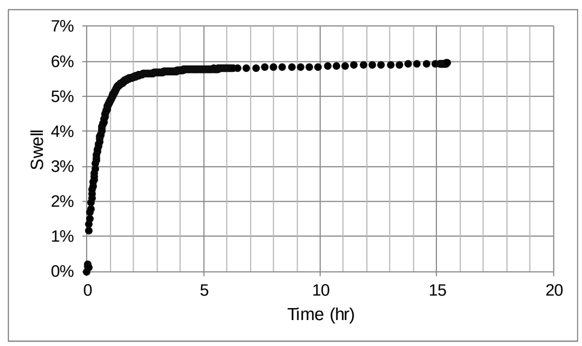
Date test conducted	8/7/2017
Centrifuge used	1
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	23.34	gravity
	Initial Moisture Content	24.0%	26.0%	%
	Mass Soil Added	37.57	37.57	g
	Dry Unit Weight	14.79	14.61	kN/m3
	Height of Sample	1.000	0.992	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.018	cm
	Testing Height	0.988	1.046	cm
	Void Ratio, e	0.840	0.949	-
	Moisture Content	26.0%	39.4%	%
	Saturation	84.9%	100.0%	%
	Change in Moisture Content	-	13.4%	%
	Overburden Mass	-	141.26	g
	Height of Water	2.27	-	cm
	Primary Swell	-	5.3%	%
	Ultimate Swell	-	5.9%	%

NOTES	2% HL; 56 Day Cure



Primary Swell (%)	5.3%	Ultimate Swell (%)	5.9%
Slope of Primary Swelling	3.92% % per log cycle	Time to Swell (hr)	1.29
Slope of Secondary Swelling	0.50% % per log cycle	Stress (psf)	363

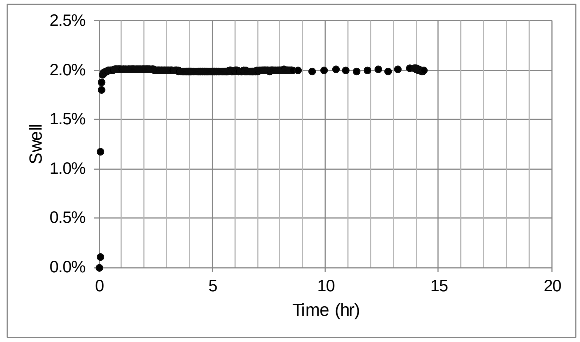
Date test conducted	7/6/2017	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	17.63	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	37.95	37.84	g
	Dry Unit Weight	14.88	14.86	kN/m3
	Height of Sample	1.000	0.996	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.082	cm
	Testing Height	0.995	1.015	cm
	Void Ratio, e	0.809	0.846	-
	Moisture Content	23.9%	39.1%	%
	Saturation	80.8%	100.0%	%
	Change in Moisture Content	-	15.2%	%
	Overburden Mass	-	39.90	g
	Height of Water	2.28	-	cm
	Primary Swell	-	1.9%	%
	Ultimate Swell	-	2.0%	%

NOTES	4% HL; 1 Day Mellow



Primary Swell (%)	1.9%	Ultimate Swell (%)	2.0%
Slope of Primary Swelling	7.63% % per log cycle	Time to Swell (hr)	0.11
Slope of Secondary Swelling	0.02% % per log cycle	Stress (psf)	101

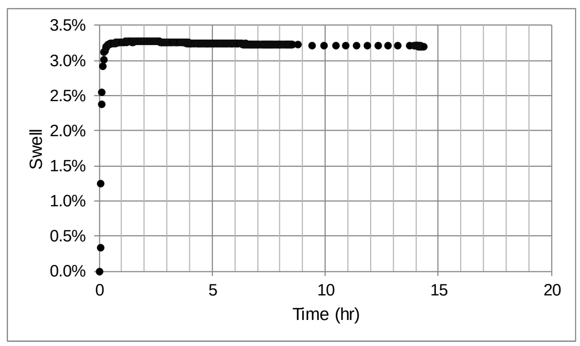
Date test conducted	7/6/2017	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	17.63	gravity
	Initial Moisture Content	24.0%	24.3%	%
	Mass Soil Added	37.95	37.82	g
	Dry Unit Weight	14.82	14.73	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.190	cm
	Testing Height	1.000	1.033	cm
	Void Ratio, e	0.825	0.885	-
	Moisture Content	24.3%	34.9%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	10.6%	%
	Overburden Mass	-	41.25	g
	Height of Water	2.29	-	cm
	Primary Swell	-	3.2%	%
	Ultimate Swell	-	3.3%	%

NOTES	4% HL; 1 Day Mellow



Primary Swell (%)	3.2%	Ultimate Swell (%)	3.3%
Slope of Primary Swelling	2.08% % per log cycle	Time to Swell (hr)	0.28
Slope of Secondary Swelling	-0.04% % per log cycle	Stress (psf)	103

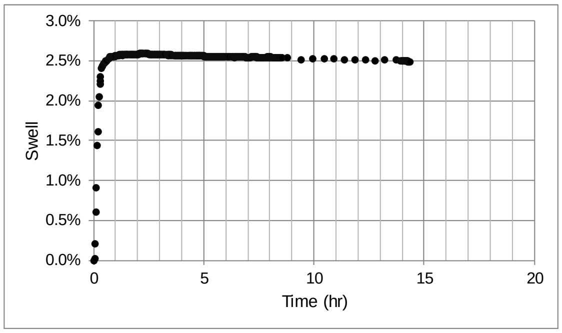
Date test conducted	7/6/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	17.63	gravity
	Initial Moisture Content	24.0%	24.2%	%
	Mass Soil Added	37.95	37.90	g
	Dry Unit Weight	14.80	14.76	kN/m3
	Height of Sample	1.000	1.001	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.074	cm
	Testing Height	1.001	1.027	cm
	Void Ratio, e	0.821	0.869	-
	Moisture Content	24.2%	33.5%	%
	Saturation	80.8%	100.0%	%
	Change in Moisture Content	-	9.3%	%
	Overburden Mass	-	73.77	g
	Height of Water	2.30	-	cm
	Primary Swell	-	2.4%	%
	Ultimate Swell	-	2.6%	%

NOTES	4% HL; 1 Day Mellow



Primary Swell (%)	2.4%		Ultimate Swell (%)	2.6%
Slope of Primary Swelling	3.34%	% per log cycle	Time to Swell (hr)	0.38
Slope of Secondary Swelling	-0.02%	% per log cycle	Stress (psf)	159

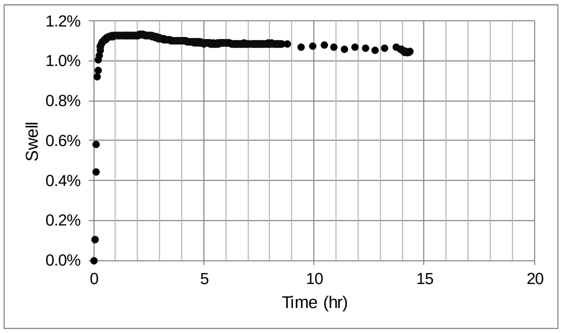
Date test conducted	7/6/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	17.63	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	37.95	37.89	g
	Dry Unit Weight	14.89	14.92	kN/m3
	Height of Sample	1.000	0.995	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.055	cm
	Testing Height	0.995	1.006	cm
	Void Ratio, e	0.801	0.821	-
	Moisture Content	23.5%	31.3%	%
	Saturation	80.4%	100.0%	%
	Change in Moisture Content	-	7.8%	%
	Overburden Mass	-	141.12	g
	Height of Water	2.29	-	cm
	Primary Swell	-	1.1%	%
	Ultimate Swell	-	1.1%	%

NOTES	4% HL; 1 Day Mellow



Primary Swell (%)	1.1%		Ultimate Swell (%)	1.1%
Slope of Primary Swelling	1.69%	% per log cycle	Time to Swell (hr)	0.28
Slope of Secondary Swelling	-0.05%	% per log cycle	Stress (psf)	274

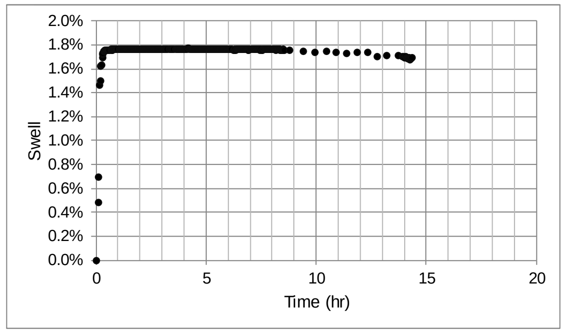
Date test conducted	7/6/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	**Soil**	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	**G-Level**	20.00	17.63	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	37.94	37.90	g
	Dry Unit Weight	14.85	14.82	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	**Seating Height**	-	0.055	cm
	Testing Height	0.998	1.016	cm
	Void Ratio, e	0.814	0.846	-
	Moisture Content	24.1%	32.2%	%
	Saturation	81.0%	100.0%	%
	Change in Moisture Content	-	8.2%	%
	Overburden Mass	-	140.54	g
	Height of Water	2.29	-	cm
	Primary Swell	-	1.6%	%
	Ultimate Swell	-	1.8%	%

NOTES	4% HL; 1 Day Mellow



Primary Swell (%)	**1.6%**	
Slope of Primary Swelling	3.36%	% per log cycle
Slope of Secondary Swelling	0.00%	% per log cycle

Ultimate Swell (%)	**1.8%**
Time to Swell (hr)	**0.24**
Stress (psf)	**273**

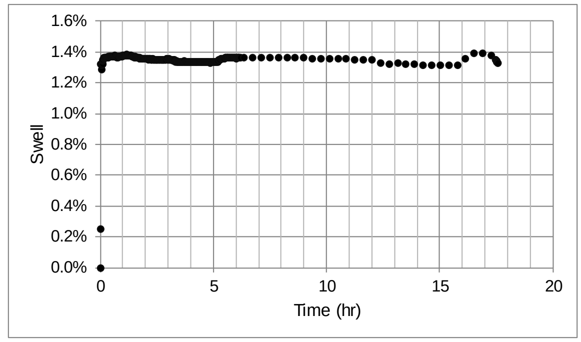
Date test conducted	7/11/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	24.34	gravity
	Initial Moisture Content	24.0%	24.3%	%
	Mass Soil Added	37.93	37.75	g
	Dry Unit Weight	14.91	14.83	kN/m3
	Height of Sample	1.000	0.993	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.068	cm
	Testing Height	0.991	1.004	cm
	Void Ratio, e	0.812	0.837	-
	Moisture Content	24.3%	32.9%	%
	Saturation	82.1%	100.0%	%
	Change in Moisture Content	-	8.6%	%
	Overburden Mass	-	39.93	g
	Height of Water	2.28	-	cm
	Primary Swell	-	1.3%	%
	Ultimate Swell	-	1.4%	%

NOTES	4% HL; 6 Day Mellow



Primary Swell (%)	1.3%	
Slope of Primary Swelling	1.77%	% per log cycle
Slope of Secondary Swelling	-0.03%	% per log cycle

Ultimate Swell (%)	1.4%
Time to Swell (hr)	0.09
Stress (psf)	139

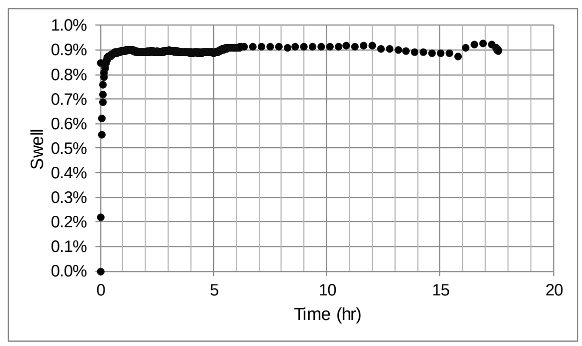
Date test conducted	7/11/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	24.34	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.93	37.78	g
	Dry Unit Weight	14.85	14.73	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.033	cm
	Testing Height	0.996	1.005	cm
	Void Ratio, e	0.825	0.842	-
	Moisture Content	24.6%	33.1%	%
	Saturation	81.8%	100.0%	%
	Change in Moisture Content	-	8.4%	%
	Overburden Mass	-	40.29	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.9%	%

NOTES	4% HL; 6 Day Mellow



Primary Swell (%)	0.8%	
Slope of Primary Swelling	0.63%	% per log cycle
Slope of Secondary Swelling	0.02%	% per log cycle

Ultimate Swell (%)	0.9%
Time to Swell (hr)	0.23
Stress (psf)	140

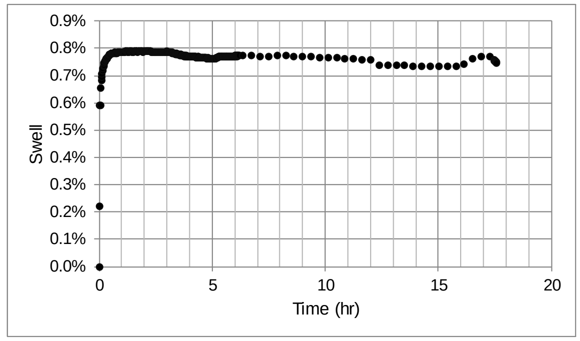
Date test conducted	7/11/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	24.34	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.94	37.80	g
	Dry Unit Weight	14.88	14.79	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.057	cm
	Testing Height	0.993	1.001	cm
	Void Ratio, e	0.818	0.832	-
	Moisture Content	24.6%	32.6%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	8.0%	%
	Overburden Mass	-	74.04	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	4% HL; 6 Day Mellow



Primary Swell (%)	0.8%		Ultimate Swell (%)	0.8%
Slope of Primary Swelling	0.28%	% per log cycle	Time to Swell (hr)	0.36
Slope of Secondary Swelling	-0.03%	% per log cycle	Stress (psf)	220

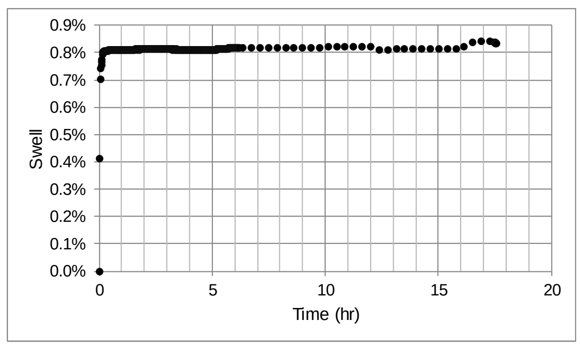
Date test conducted	7/11/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	24.34	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	37.93	37.81	g
	Dry Unit Weight	14.94	14.84	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.017	cm
	Testing Height	0.991	1.000	cm
	Void Ratio, e	0.811	0.826	-
	Moisture Content	24.4%	31.9%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	7.5%	%
	Overburden Mass	-	73.81	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	4% HL; 6 Day Mellow



Primary Swell (%)	0.8%		Ultimate Swell (%)	0.8%
Slope of Primary Swelling	0.88%	% per log cycle	Time to Swell (hr)	0.17
Slope of Secondary Swelling	0.01%	% per log cycle	Stress (psf)	219

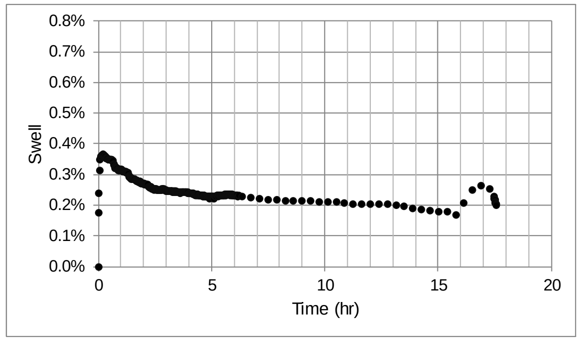
Date test conducted	7/11/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	24.34	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	37.93	37.84	g
	Dry Unit Weight	14.88	14.84	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.045	cm
	Testing Height	0.992	0.996	cm
	Void Ratio, e	0.811	0.818	-
	Moisture Content	24.4%	32.7%	%
	Saturation	82.4%	100.0%	%
	Change in Moisture Content	-	8.3%	%
	Overburden Mass	-	142.89	g
	Height of Water	2.28	-	cm
	Primary Swell	-	0.4%	%
	Ultimate Swell	-	0.4%	%

NOTES	4% HL; 6 Day Mellow



Primary Swell (%)	0.4%	
Slope of Primary Swelling	0.29%	% per log cycle
Slope of Secondary Swelling	-0.10%	% per log cycle

Ultimate Swell (%)	0.4%
Time to Swell (hr)	0.13
Stress (psf)	382

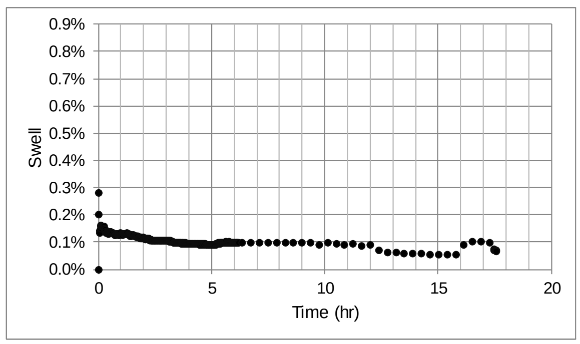
Date test conducted	7/11/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	24.34	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.94	37.85	g
	Dry Unit Weight	14.87	14.77	kN/m3
	Height of Sample	1.000	0.996	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.069	cm
	Testing Height	0.995	0.997	cm
	Void Ratio, e	0.820	0.823	-
	Moisture Content	24.6%	32.7%	%
	Saturation	82.2%	100.0%	%
	Change in Moisture Content	-	8.1%	%
	Overburden Mass	-	140.54	g
	Height of Water	2.30	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	4% HL; 6 Day Mellow



Primary Swell (%)	0.2%	
Slope of Primary Swelling	0.04%	% per log cycle
Slope of Secondary Swelling	-0.03%	% per log cycle

Ultimate Swell (%)	0.2%
Time to Swell (hr)	0.17
Stress (psf)	377

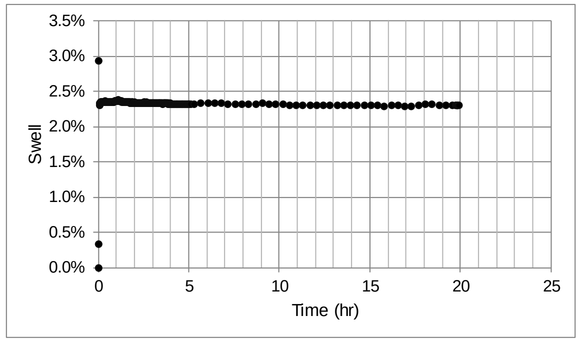
Date test conducted	7/25/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	17.22	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	37.25	37.07	g
	Dry Unit Weight	14.65	14.56	kN/m3
	Height of Sample	1.000	0.993	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.060	cm
	Testing Height	0.986	1.015	cm
	Void Ratio, e	0.846	0.900	-
	Moisture Content	24.9%	36.0%	%
	Saturation	80.8%	100.0%	%
	Change in Moisture Content	-	11.0%	%
	Overburden Mass	-	39.47	g
	Height of Water	2.31	-	cm
	Primary Swell	-	2.3%	%
	Ultimate Swell	-	2.9%	%

NOTES	4% HL; 43 Day Mellow



Primary Swell (%)	2.3%	
Slope of Primary Swelling	4.11%	% per log cycle
Slope of Secondary Swelling	-0.06%	% per log cycle

Ultimate Swell (%)	2.9%
Time to Swell (hr)	0.08
Stress (psf)	97

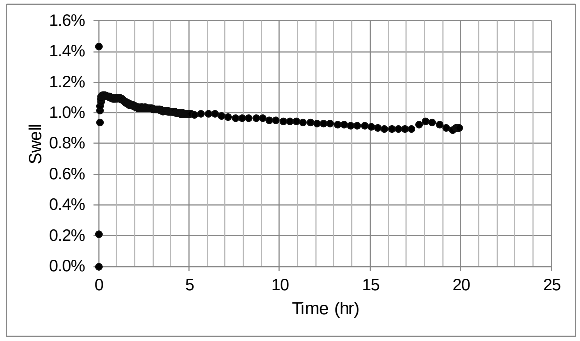
Date test conducted	7/25/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	17.22	gravity
	Initial Moisture Content	24.0%	25.1%	%
	Mass Soil Added	37.23	37.12	g
	Dry Unit Weight	14.56	14.42	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.020	cm
	Testing Height	0.996	1.011	cm
	Void Ratio, e	0.864	0.891	-
	Moisture Content	25.1%	35.3%	%
	Saturation	79.5%	100.0%	%
	Change in Moisture Content	-	10.2%	%
	Overburden Mass	-	73.05	g
	Height of Water	2.30	-	cm
	Primary Swell	-	1.0%	%
	Ultimate Swell	-	1.4%	%

NOTES	
	4% HL; 43 Day Mellow



Primary Swell (%)	1.0%	Ultimate Swell (%)	1.4%
Slope of Primary Swelling	1.52% % per log cycle	Time to Swell (hr)	0.09
Slope of Secondary Swelling	-0.17% % per log cycle	Stress (psf)	153

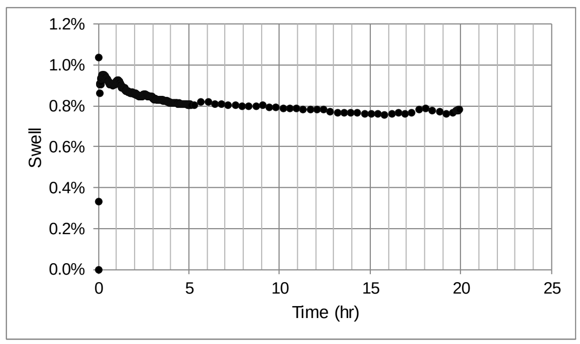
Date test conducted	7/25/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	17.22	gravity
	Initial Moisture Content	24.0%	24.9%	%
	Mass Soil Added	37.24	37.15	g
	Dry Unit Weight	14.55	14.45	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.029	cm
	Testing Height	0.996	1.006	cm
	Void Ratio, e	0.860	0.879	-
	Moisture Content	24.9%	34.6%	%
	Saturation	79.4%	100.0%	%
	Change in Moisture Content	-	9.7%	%
	Overburden Mass	-	73.62	g
	Height of Water	2.27	-	cm
	Primary Swell	-	0.9%	%
	Ultimate Swell	-	1.0%	%

NOTES	
	4% HL; 43 Day Mellow



Primary Swell (%)	0.9%	Ultimate Swell (%)	1.0%
Slope of Primary Swelling	1.11% % per log cycle	Time to Swell (hr)	0.09
Slope of Secondary Swelling	-0.13% % per log cycle	Stress (psf)	155

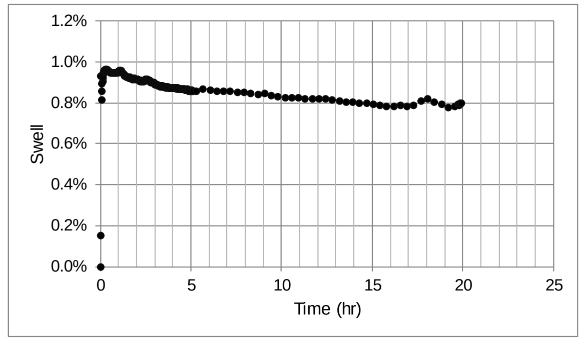
Date test conducted	7/25/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	17.22	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.24	37.08	g
	Dry Unit Weight	14.55	14.45	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.004	cm
	Testing Height	0.997	1.006	cm
	Void Ratio, e	0.860	0.878	-
	Moisture Content	24.6%	34.2%	%
	Saturation	78.3%	100.0%	%
	Change in Moisture Content	-	9.6%	%
	Overburden Mass	-	140.95	g
	Height of Water	2.29	-	cm
	Primary Swell	-	0.9%	%
	Ultimate Swell	-	1.0%	%

NOTES	4% HL; 43 Day Mellow



Primary Swell (%)	0.9%	Ultimate Swell (%)	1.0%
Slope of Primary Swelling	1.37% % per log cycle	Time to Swell (hr)	0.09
Slope of Secondary Swelling	-0.14% % per log cycle	Stress (psf)	267

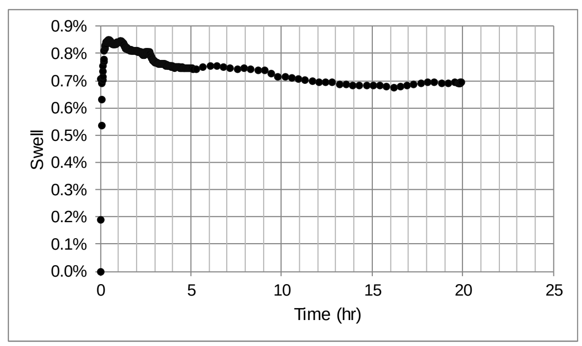
Date test conducted	7/25/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	17.22	gravity
	Initial Moisture Content	24.0%	25.5%	%
	Mass Soil Added	37.23	37.15	g
	Dry Unit Weight	14.74	14.56	kN/m3
	Height of Sample	1.000	0.986	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.038	cm
	Testing Height	0.984	0.992	cm
	Void Ratio, e	0.846	0.862	-
	Moisture Content	25.5%	33.8%	%
	Saturation	82.7%	100.0%	%
	Change in Moisture Content	-	8.2%	%
	Overburden Mass	-	142.31	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.9%	%

NOTES	4% HL; 43 Day Mellow



Primary Swell (%)	0.8%	Ultimate Swell (%)	0.9%
Slope of Primary Swelling	0.72% % per log cycle	Time to Swell (hr)	0.21
Slope of Secondary Swelling	-0.12% % per log cycle	Stress (psf)	269

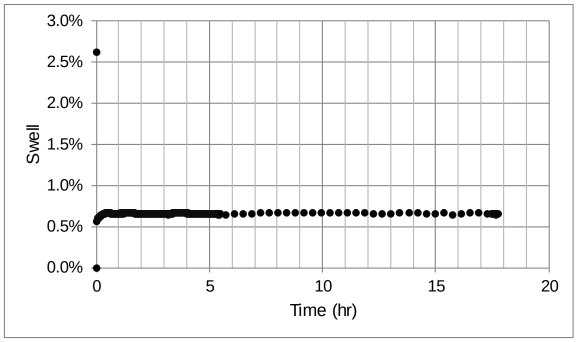
Date test conducted	7/24/2017	
Centrifuge used	2	
Cup Number	1	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.42	gravity
	Initial Moisture Content	24.0%	24.4%	%
	Mass Soil Added	37.79	37.79	g
	Dry Unit Weight	14.87	14.93	kN/m3
	Height of Sample	1.000	0.992	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.054	cm
	Testing Height	0.985	0.991	cm
	Void Ratio, e	0.801	0.813	-
	Moisture Content	24.4%	31.1%	%
	Saturation	83.6%	100.0%	%
	Change in Moisture Content	-	6.6%	%
	Overburden Mass	-	40.08	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.7%	%
	Ultimate Swell	-	0.7%	%

NOTES	4% HL; 42 Day Cure



Primary Swell (%)	0.7%	
Ultimate Swell (%)	0.7%	
Slope of Primary Swelling	0.07%	% per log cycle
Time to Swell (hr)	0.58	
Slope of Secondary Swelling	-0.01%	% per log cycle
Stress (psf)	116	

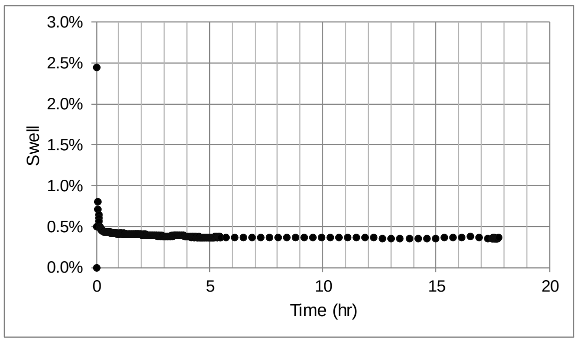
Date test conducted	7/24/2017	
Centrifuge used	2	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.42	gravity
	Initial Moisture Content	24.0%	23.9%	%
	Mass Soil Added	37.51	37.51	g
	Dry Unit Weight	14.69	14.77	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.045	cm
	Testing Height	0.992	0.997	cm
	Void Ratio, e	0.819	0.829	-
	Moisture Content	23.9%	31.4%	%
	Saturation	79.8%	100.0%	%
	Change in Moisture Content	-	7.6%	%
	Overburden Mass	-	39.99	g
	Height of Water	2.29	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.5%	%

NOTES	4% HL; 42 Day Cure



Primary Swell (%)	0.5%	
Ultimate Swell (%)	0.5%	
Slope of Primary Swelling	-0.58%	% per log cycle
Time to Swell (hr)	0.25	
Slope of Secondary Swelling	-0.05%	% per log cycle
Stress (psf)	116	

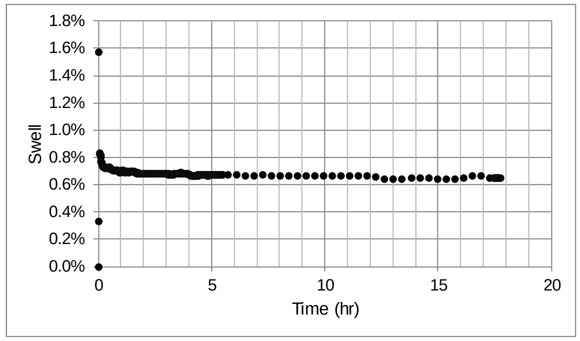
Date test conducted	7/24/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	26%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	20.42	gravity
	Initial Moisture Content	24.0%	25.5%	%
	Mass Soil Added	37.06	37.06	g
	Dry Unit Weight	14.56	14.43	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.047	cm
	Testing Height	0.990	0.998	cm
	Void Ratio, e	0.863	0.877	-
	Moisture Content	25.5%	32.2%	%
	Saturation	81.1%	100.0%	%
	Change in Moisture Content	-	6.7%	%
	Overburden Mass	-	73.48	g
	Height of Water	2.31	-	cm
	Primary Swell	-	0.7%	%
	Ultimate Swell	-	0.8%	%

NOTES	4% HL; 42 Day Cure



Primary Swell (%)	0.7%		Ultimate Swell (%)	0.8%	
Slope of Primary Swelling	-0.17%	% per log cycle	Time to Swell (hr)	0.21	
Slope of Secondary Swelling	-0.05%	% per log cycle	Stress (psf)	183	

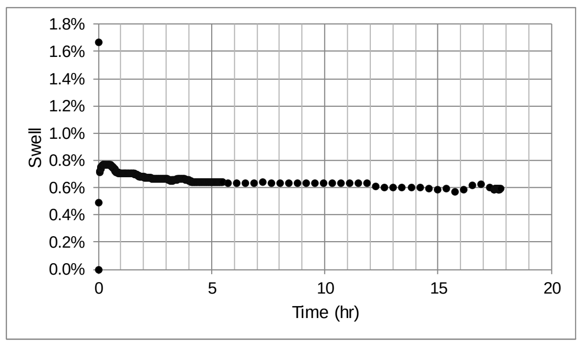
Date test conducted	7/24/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	20.42	gravity
	Initial Moisture Content	24.0%	24.0%	%
	Mass Soil Added	37.41	37.41	g
	Dry Unit Weight	14.86	14.99	kN/m3
	Height of Sample	1.000	0.983	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.049	cm
	Testing Height	0.974	0.981	cm
	Void Ratio, e	0.793	0.807	-
	Moisture Content	24.0%	31.1%	%
	Saturation	83.0%	100.0%	%
	Change in Moisture Content	-	7.1%	%
	Overburden Mass	-	73.68	g
	Height of Water	2.32	-	cm
	Primary Swell	-	0.8%	%
	Ultimate Swell	-	0.8%	%

NOTES	4% HL; 42 Day Cure



Primary Swell (%)	0.8%		Ultimate Swell (%)	0.8%
Slope of Primary Swelling	0.09%	% per log cycle	Time to Swell (hr)	0.31
Slope of Secondary Swelling	-0.10%	% per log cycle	Stress (psf)	183

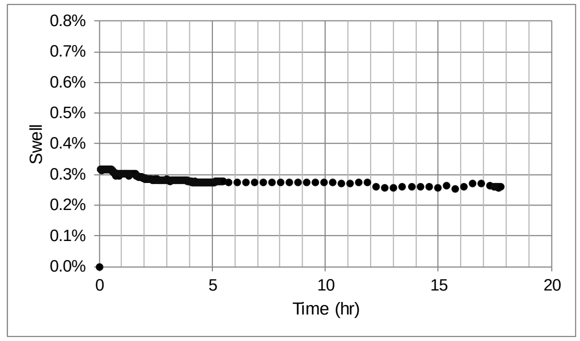
Date test conducted	7/24/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.42	gravity
	Initial Moisture Content	24.0%	24.6%	%
	Mass Soil Added	37.83	37.83	g
	Dry Unit Weight	14.81	14.81	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.069	cm
	Testing Height	0.992	0.995	cm
	Void Ratio, e	0.815	0.821	-
	Moisture Content	24.6%	31.0%	%
	Saturation	82.7%	100.0%	%
	Change in Moisture Content	-	6.4%	%
	Overburden Mass	-	141.02	g
	Height of Water	2.32	-	cm
	Primary Swell	-	0.3%	%
	Ultimate Swell	-	0.3%	%

NOTES	4% HL; 42 Day Cure



Primary Swell (%)	0.3%		Ultimate Swell (%)	0.3%
Slope of Primary Swelling	0.00%	% per log cycle	Time to Swell (hr)	0.56
Slope of Secondary Swelling	-0.04%	% per log cycle	Stress (psf)	317

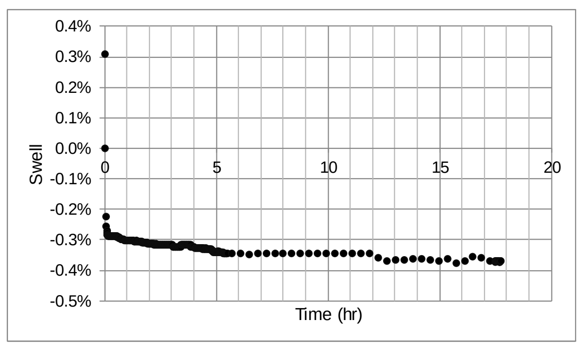
Date test conducted	7/24/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	20.42	gravity
	Initial Moisture Content	24.0%	24.1%	%
	Mass Soil Added	37.39	37.39	g
	Dry Unit Weight	14.62	14.77	kN/m3
	Height of Sample	1.000	0.998	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.027	cm
	Testing Height	0.988	0.985	cm
	Void Ratio, e	0.820	0.815	-
	Moisture Content	24.1%	31.2%	%
	Saturation	80.3%	100.0%	%
	Change in Moisture Content	-	7.2%	%
	Overburden Mass	-	140.07	g
	Height of Water	2.31	-	cm
	Primary Swell	-	-0.3%	%
	Ultimate Swell	-	-0.3%	%

NOTES	4% HL; 42 Day Cure



Primary Swell (%)	-0.3%		Ultimate Swell (%)	-0.3%
Slope of Primary Swelling	-0.10%	% per log cycle	Time to Swell (hr)	0.08
Slope of Secondary Swelling	-0.06%	% per log cycle	Stress (psf)	315

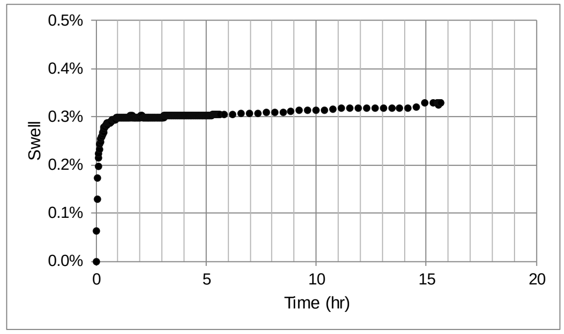
Date test conducted	8/7/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	15.18	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	36.01	36.01	g
	Dry Unit Weight	14.07	14.28	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.086	cm
	Testing Height	0.988	0.991	cm
	Void Ratio, e	0.882	0.889	-
	Moisture Content	23.5%	34.3%	%
	Saturation	73.1%	100.0%	%
	Change in Moisture Content	-	10.8%	%
	Overburden Mass	-	40.51	g
	Height of Water	2.29	-	cm
	Primary Swell	-	0.3%	%
	Ultimate Swell	-	0.3%	%

NOTES	4% HL; 56 Day Cure



Primary Swell (%)	0.3%		Ultimate Swell (%)	0.3%
Slope of Primary Swelling	0.20%	% per log cycle	Time to Swell (hr)	0.33
Slope of Secondary Swelling	0.01%	% per log cycle	Stress (psf)	87

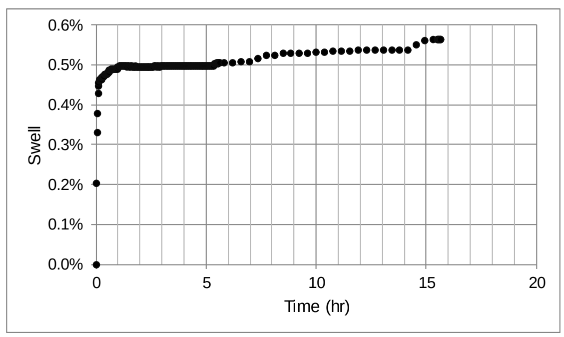
Date test conducted	8/7/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	EF
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.74

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	15.18	gravity
	Initial Moisture Content	24.0%	23.2%	%
	Mass Soil Added	37.15	37.15	g
	Dry Unit Weight	14.47	14.42	kN/m3
	Height of Sample	1.000	1.002	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.959	cm
	Testing Height	1.012	1.018	cm
	Void Ratio, e	0.864	0.874	-
	Moisture Content	23.2%	36.2%	%
	Saturation	73.6%	100.0%	%
	Change in Moisture Content	-	13.0%	%
	Overburden Mass	-	39.98	g
	Height of Water	2.32	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.6%	%

NOTES	4% HL; 56 Day Cure



Primary Swell (%)	0.5%		Ultimate Swell (%)	0.6%
Slope of Primary Swelling	0.24%	% per log cycle	Time to Swell (hr)	0.24
Slope of Secondary Swelling	0.01%	% per log cycle	Stress (psf)	87

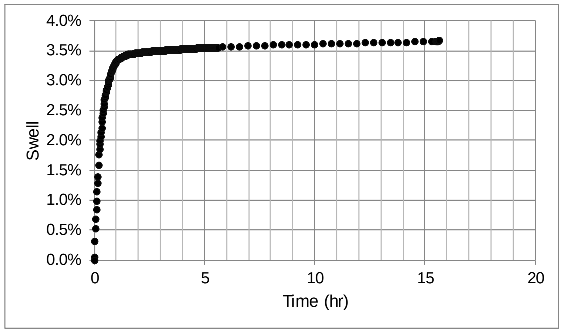
Date test conducted	8/7/2017	
Centrifuge used	3	
Cup Number	4	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	25%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	15.18	gravity
	Initial Moisture Content	24.0%	25.0%	%
	Mass Soil Added	36.95	36.95	g
	Dry Unit Weight	14.41	14.18	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.068	cm
	Testing Height	1.009	1.045	cm
	Void Ratio, e	0.895	0.965	-
	Moisture Content	25.0%	38.6%	%
	Saturation	76.6%	100.0%	%
	Change in Moisture Content	-	13.5%	%
	Overburden Mass	-	73.57	g
	Height of Water	2.27	-	cm
	Primary Swell	-	3.3%	%
	Ultimate Swell	-	3.7%	%

NOTES	4% HL; 56 Day Cure



Primary Swell (%)	3.3%		Ultimate Swell (%)	3.7%	
Slope of Primary Swelling	2.50%	% per log cycle	Time to Swell (hr)	0.96	
Slope of Secondary Swelling	0.22%	% per log cycle	Stress (psf)	136	

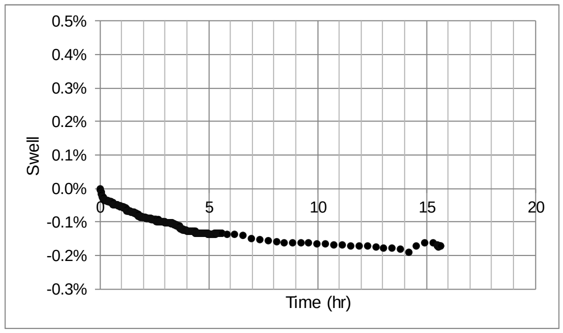
Date test conducted	8/7/2017	
Centrifuge used	3	
Cup Number	5	
Conducted by	Karly	

SOIL Information		
	Soil	EF
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.74

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	15.18	gravity
	Initial Moisture Content	24.0%	23.7%	%
	Mass Soil Added	36.81	36.81	g
	Dry Unit Weight	14.40	14.45	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.084	cm
	Testing Height	0.997	0.997	cm
	Void Ratio, e	0.861	0.860	-
	Moisture Content	23.7%	32.3%	%
	Saturation	75.4%	100.0%	%
	Change in Moisture Content	-	8.6%	%
	Overburden Mass	-	141.25	g
	Height of Water	2.32	-	cm
	Primary Swell	-	-0.1%	%
	Ultimate Swell	-	0.0%	%

NOTES	4% HL; 56 Day Cure



Primary Swell (%)	-0.1%		Ultimate Swell (%)	0.0%
Slope of Primary Swelling	-0.04%	% per log cycle	Time to Swell (hr)	1.59
Slope of Secondary Swelling	-0.11%	% per log cycle	Stress (psf)	236

APPENDIX D: US 87 B-02 CENTRIFUGE TEST RESULTS

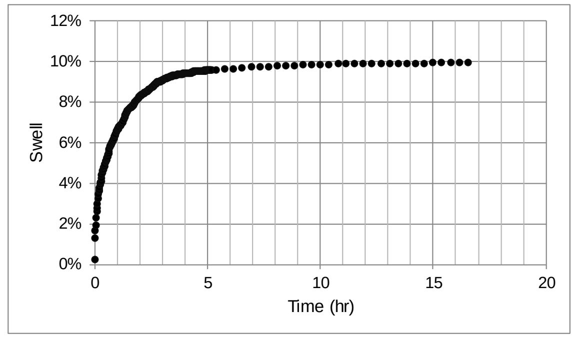
Date test conducted	6/20/2018
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.11	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	36.34	36.31	g
	Dry Unit Weight	14.39	14.49	kN/m3
	Height of Sample	1.000	0.986	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.061	cm
	Testing Height	0.983	1.081	cm
	Void Ratio, e	0.828	1.010	-
	Moisture Content	23.4%	38.9%	%
	Saturation	76.2%	100.0%	%
	Change in Moisture Content	-	15.5%	%
	Overburden Mass	-	41.15	g
	Height of Water	2.62	-	cm
	Primary Swell	-	9.3%	%
	Ultimate Swell	-	10.0%	%

NOTES	0.5' - 4' Depth



Primary Swell (%)	9.3%	
Ultimate Swell (%)	10.0%	
Slope of Primary Swelling	4.53%	% per log cycle
Time to Swell (hr)	3.64	
Slope of Secondary Swelling	0.80%	% per log cycle
Stress (psf)	129	

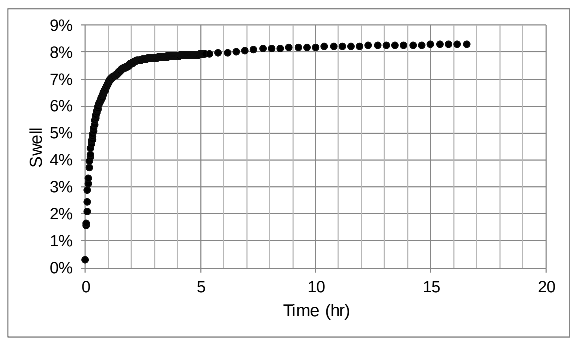
Date test conducted	6/20/2018
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.11	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	36.35	36.31	g
	Dry Unit Weight	14.15	14.38	kN/m3
	Height of Sample	1.000	1.003	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.049	cm
	Testing Height	0.990	1.072	cm
	Void Ratio, e	0.841	0.994	-
	Moisture Content	23.4%	39.3%	%
	Saturation	75.0%	100.0%	%
	Change in Moisture Content	-	16.0%	%
	Overburden Mass	-	39.40	g
	Height of Water	2.62	-	cm
	Primary Swell	-	7.7%	%
	Ultimate Swell	-	8.3%	%

NOTES	0.5' - 4' Depth



Primary Swell (%)	7.7%	
Ultimate Swell (%)	8.3%	
Slope of Primary Swelling	3.46%	% per log cycle
Time to Swell (hr)	2.13	
Slope of Secondary Swelling	0.74%	% per log cycle
Stress (psf)	125	

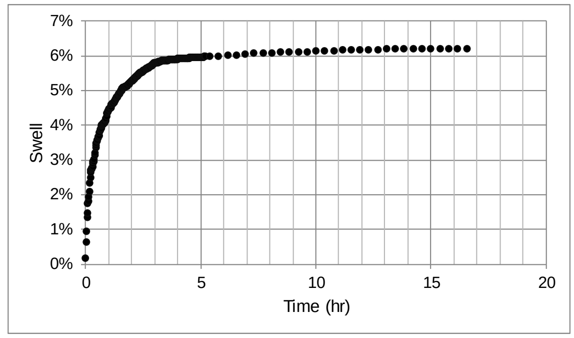
Date test conducted	6/20/2018
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.11	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	36.36	36.33	g
	Dry Unit Weight	14.28	14.47	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.056	cm
	Testing Height	0.984	1.045	cm
	Void Ratio, e	0.830	0.944	-
	Moisture Content	23.5%	39.6%	%
	Saturation	76.4%	100.0%	%
	Change in Moisture Content	-	16.1%	%
	Overburden Mass	-	73.64	g
	Height of Water	2.63	-	cm
	Primary Swell	-	5.8%	%
	Ultimate Swell	-	6.2%	%

NOTES	0.5' - 4' Depth



Primary Swell (%)	5.8%		Ultimate Swell (%)	6.2%
Slope of Primary Swelling	2.86%	% per log cycle	Time to Swell (hr)	3.23
Slope of Secondary Swelling	0.51%	% per log cycle	Stress (psf)	198

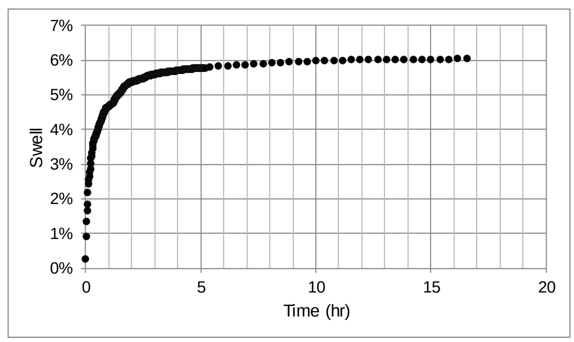
Date test conducted	6/20/2018
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	24%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.11	gravity
	Initial Moisture Content	24.0%	23.6%	%
	Mass Soil Added	36.34	36.31	g
	Dry Unit Weight	14.12	14.34	kN/m3
	Height of Sample	1.000	1.004	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.053	cm
	Testing Height	0.991	1.051	cm
	Void Ratio, e	0.847	0.958	-
	Moisture Content	23.6%	39.2%	%
	Saturation	75.2%	100.0%	%
	Change in Moisture Content	-	15.7%	%
	Overburden Mass	-	74.17	g
	Height of Water	2.62	-	cm
	Primary Swell	-	5.5%	%
	Ultimate Swell	-	6.0%	%

NOTES	0.5' - 4' Depth



Primary Swell (%)	5.5%		Ultimate Swell (%)	6.0%
Slope of Primary Swelling	2.43%	% per log cycle	Time to Swell (hr)	2.61
Slope of Secondary Swelling	0.54%	% per log cycle	Stress (psf)	200

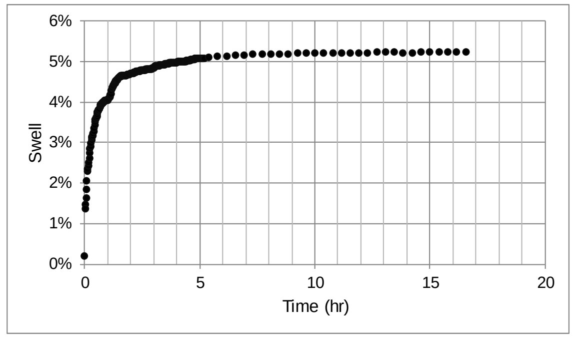
Date test conducted	6/20/2018
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.11	gravity
	Initial Moisture Content	24.0%	23.5%	%
	Mass Soil Added	36.36	36.34	g
	Dry Unit Weight	14.14	14.31	kN/m3
	Height of Sample	1.000	1.004	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.055	cm
	Testing Height	0.995	1.048	cm
	Void Ratio, e	0.851	0.948	-
	Moisture Content	23.5%	39.9%	%
	Saturation	74.5%	100.0%	%
	Change in Moisture Content	-	16.4%	%
	Overburden Mass	-	139.72	g
	Height of Water	2.62	-	cm
	Primary Swell	-	4.8%	%
	Ultimate Swell	-	5.2%	%

NOTES	0.5' - 4' Depth



Primary Swell (%)	4.8%		Ultimate Swell (%)	5.2%
Slope of Primary Swelling	2.02%	% per log cycle	Time to Swell (hr)	2.67
Slope of Secondary Swelling	0.41%	% per log cycle	Stress (psf)	340

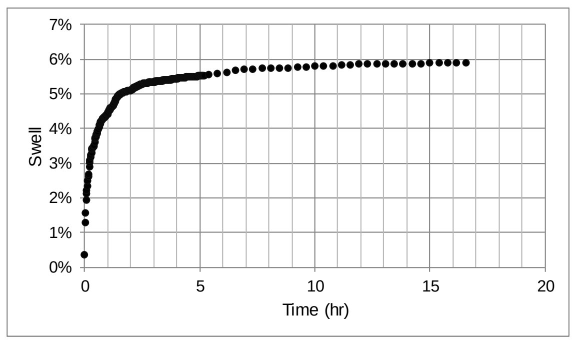
Date test conducted	6/20/2018
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	22.11	gravity
	Initial Moisture Content	24.0%	23.4%	%
	Mass Soil Added	36.35	36.34	g
	Dry Unit Weight	14.14	14.30	kN/m3
	Height of Sample	1.000	1.003	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.064	cm
	Testing Height	0.996	1.055	cm
	Void Ratio, e	0.852	0.961	-
	Moisture Content	23.4%	38.5%	%
	Saturation	74.3%	100.0%	%
	Change in Moisture Content	-	15.0%	%
	Overburden Mass	-	141.78	g
	Height of Water	2.62	-	cm
	Primary Swell	-	5.3%	%
	Ultimate Swell	-	5.9%	%

NOTES	0.5' - 4' Depth



Primary Swell (%)	5.3%		Ultimate Swell (%)	5.9%
Slope of Primary Swelling	2.25%	% per log cycle	Time to Swell (hr)	2.40
Slope of Secondary Swelling	0.75%	% per log cycle	Stress (psf)	344

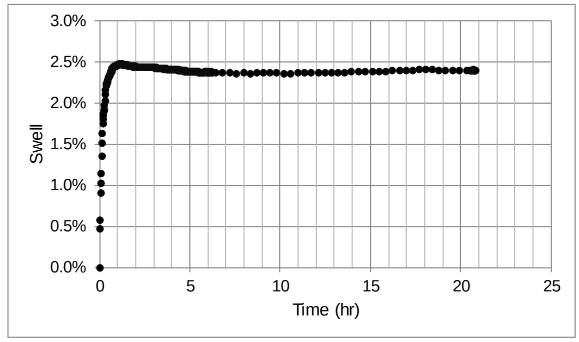
Date test conducted	8/8/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information	Soil	4% HL
	Target Water Content	23%
	Water Content	23%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	27.06	gravity
	Initial Moisture Content	23.0%	22.6%	%
	Mass Soil Added	37.77	37.71	g
	Dry Unit Weight	14.86	14.93	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.060	cm
	Testing Height	0.997	1.022	cm
	Void Ratio, e	0.774	0.818	-
	Moisture Content	22.6%	32.7%	%
	Saturation	78.7%	100.0%	%
	Change in Moisture Content	-	10.1%	%
	Overburden Mass	-	40.41	g
	Height of Water	2.42	-	cm
	Primary Swell	-	2.3%	%
	Ultimate Swell	-	2.5%	%

NOTES	0.5' - 4' Depth; 4% HL



Primary Swell (%)	2.3%	Ultimate Swell (%)	2.5%
Slope of Primary Swelling	1.74% % per log cycle	Time to Swell (hr)	0.56
Slope of Secondary Swelling	-0.04% % per log cycle	Stress (psf)	156

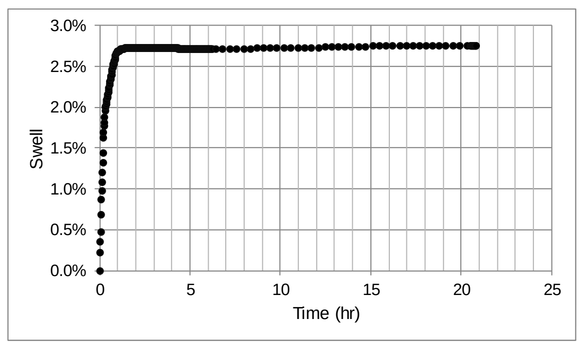
Date test conducted	8/8/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information	Soil	4% HL
	Target Water Content	23%
	Water Content	23%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	27.06	gravity
	Initial Moisture Content	23.0%	23.3%	%
	Mass Soil Added	37.77	37.73	g
	Dry Unit Weight	14.89	14.87	kN/m3
	Height of Sample	1.000	0.998	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.062	cm
	Testing Height	0.996	1.023	cm
	Void Ratio, e	0.781	0.830	-
	Moisture Content	23.3%	32.8%	%
	Saturation	80.4%	100.0%	%
	Change in Moisture Content	-	9.5%	%
	Overburden Mass	-	39.89	g
	Height of Water	2.40	-	cm
	Primary Swell	-	2.7%	%
	Ultimate Swell	-	2.8%	%

NOTES	0.5' - 4' Depth; 4% HL



Primary Swell (%)	2.7%	Ultimate Swell (%)	2.8%
Slope of Primary Swelling	1.89% % per log cycle	Time to Swell (hr)	0.93
Slope of Secondary Swelling	0.04% % per log cycle	Stress (psf)	154

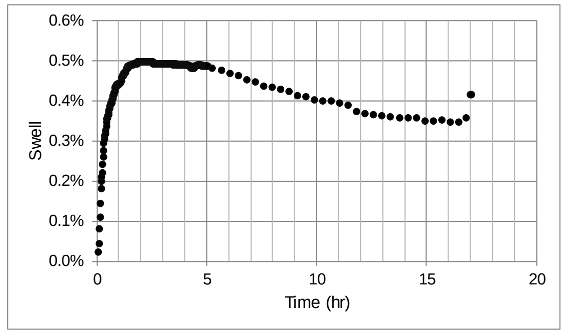
	Date test conducted	6/19/2018	
	Centrifuge used	2	
	Cup Number	1	
	Conducted by	Karly	

SOIL Information	Soil	US 87 B-02		
	Target Water Content	24%		
	Water Content	21%		
	Specific Gravity	2.70		

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.30	gravity
	Initial Moisture Content	24.0%	20.7%	%
	Mass Soil Added	36.35	36.15	g
	Dry Unit Weight	14.04	14.35	kN/m3
	Height of Sample	1.000	1.010	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.015	cm
	Testing Height	1.010	1.015	cm
	Void Ratio, e	0.845	0.855	-
	Moisture Content	20.7%	34.6%	%
	Saturation	66.2%	100.0%	%
	Change in Moisture Content	-	13.8%	%
	Overburden Mass	-	40.41	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.5%	%
	Ultimate Swell	-	0.5%	%

NOTES	0.5' - 4' 4% HL



Primary Swell (%)	0.5%	Ultimate Swell (%)	0.5%
Slope of Primary Swelling	0.43% % per log cycle	Time to Swell (hr)	1.91
Slope of Secondary Swelling	-0.23% % per log cycle	Stress (psf)	105

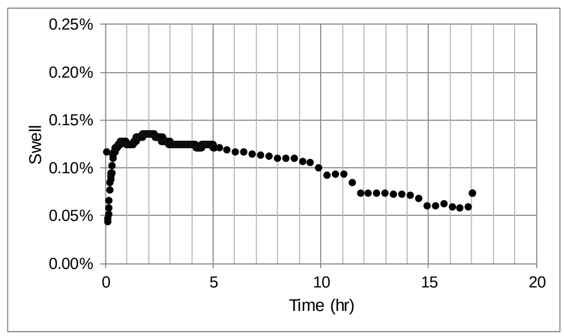
	Date test conducted	6/19/2018	
	Centrifuge used	2	
	Cup Number	2	
	Conducted by	Karly	

SOIL Information	Soil	US 87 B-02		
	Target Water Content	24%		
	Water Content	22%		
	Specific Gravity	2.70		

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	20.00	18.30	gravity
	Initial Moisture Content	24.0%	21.9%	%
	Mass Soil Added	36.32	36.23	g
	Dry Unit Weight	14.14	14.35	kN/m3
	Height of Sample	1.000	1.003	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.011	cm
	Testing Height	1.002	1.003	cm
	Void Ratio, e	0.845	0.848	-
	Moisture Content	21.9%	33.0%	%
	Saturation	70.1%	100.0%	%
	Change in Moisture Content	-	11.0%	%
	Overburden Mass	-	40.56	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.1%	%
	Ultimate Swell	-	0.1%	%

NOTES	0.5' - 4' 4% HL



Primary Swell (%)	0.1%	Ultimate Swell (%)	0.1%
Slope of Primary Swelling	0.33% % per log cycle	Time to Swell (hr)	0.72
Slope of Secondary Swelling	-0.10% % per log cycle	Stress (psf)	105

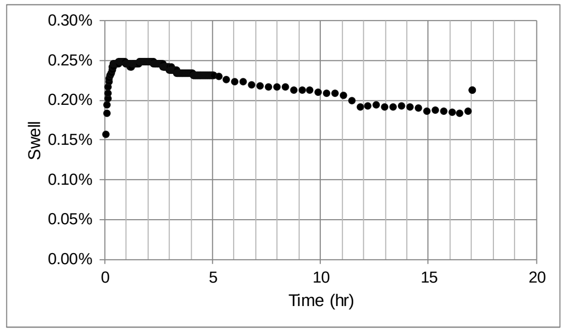
Date test conducted	6/19/2018	
Centrifuge used	2	
Cup Number	3	
Conducted by	Karly	

SOIL Information	Soil	US 87 B-02
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	18.30	gravity
	Initial Moisture Content	24.0%	22.0%	%
	Mass Soil Added	36.33	36.24	g
	Dry Unit Weight	14.18	14.40	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.008	cm
	Testing Height	0.999	1.001	cm
	Void Ratio, e	0.840	0.844	-
	Moisture Content	22.0%	31.6%	%
	Saturation	70.7%	100.0%	%
	Change in Moisture Content	-	9.6%	%
	Overburden Mass	-	73.62	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.2%	%
	Ultimate Swell	-	0.2%	%

NOTES	0.5' - 4' 4% HL



Primary Swell (%)	0.2%		Ultimate Swell (%)	0.2%
Slope of Primary Swelling	0.37%	% per log cycle	Time to Swell (hr)	0.58
Slope of Secondary Swelling	-0.08%	% per log cycle	Stress (psf)	164

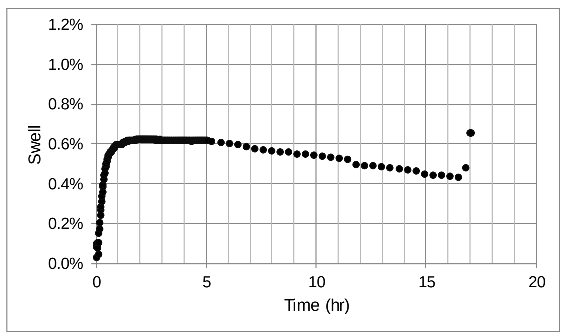
Date test conducted	6/19/2018	
Centrifuge used	2	
Cup Number	4	
Conducted by	Karly	

SOIL Information	Soil	US 87 B-02
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	18.30	gravity
	Initial Moisture Content	24.0%	22.2%	%
	Mass Soil Added	36.33	36.26	g
	Dry Unit Weight	14.09	14.31	kN/m3
	Height of Sample	1.000	1.006	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.072	cm
	Testing Height	1.003	1.010	cm
	Void Ratio, e	0.851	0.863	-
	Moisture Content	22.2%	32.7%	%
	Saturation	70.5%	100.0%	%
	Change in Moisture Content	-	10.4%	%
	Overburden Mass	-	74.25	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.6%	%
	Ultimate Swell	-	0.7%	%

NOTES	0.5' - 4' 4% HL



Primary Swell (%)	0.6%		Ultimate Swell (%)	0.7%
Slope of Primary Swelling	0.68%	% per log cycle	Time to Swell (hr)	1.08
Slope of Secondary Swelling	-0.26%	% per log cycle	Stress (psf)	165

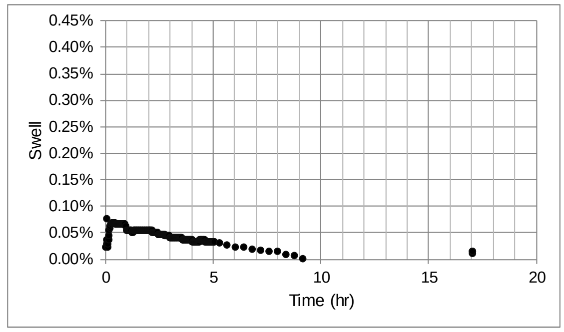
Date test conducted	6/19/2018	
Centrifuge used	2	
Cup Number	5	
Conducted by	Karly	

SOIL Information	Soil	US 87 B-02
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	18.30	gravity
	Initial Moisture Content	24.0%	21.8%	%
	Mass Soil Added	36.34	36.27	g
	Dry Unit Weight	14.18	14.42	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.028	cm
	Testing Height	0.999	1.000	cm
	Void Ratio, e	0.836	0.838	-
	Moisture Content	21.8%	31.3%	%
	Saturation	70.5%	100.0%	%
	Change in Moisture Content	-	9.4%	%
	Overburden Mass	-	141.14	g
	Height of Water	2.63	-	cm
	Primary Swell	-	0.1%	%
	Ultimate Swell	-	0.1%	%

NOTES	0.5' - 4' 4% HL



Primary Swell (%)	0.1%		Ultimate Swell (%)	0.1%
Slope of Primary Swelling	0.12%	% per log cycle	Time to Swell (hr)	0.43
Slope of Secondary Swelling	-0.06%	% per log cycle	Stress (psf)	284

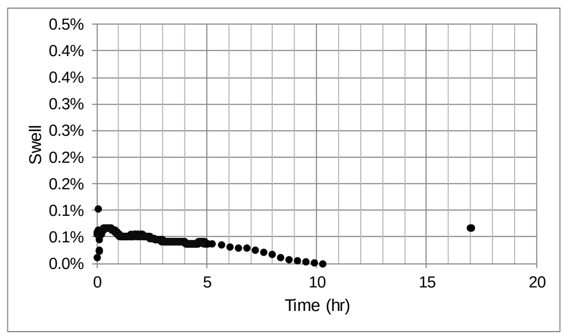
Date test conducted	6/19/2018	
Centrifuge used	2	
Cup Number	6	
Conducted by	Karly	

SOIL Information	Soil	US 87 B-02
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	20.00	18.30	gravity
	Initial Moisture Content	24.0%	22.1%	%
	Mass Soil Added	36.32	36.27	g
	Dry Unit Weight	14.20	14.43	kN/m3
	Height of Sample	1.000	0.998	cm

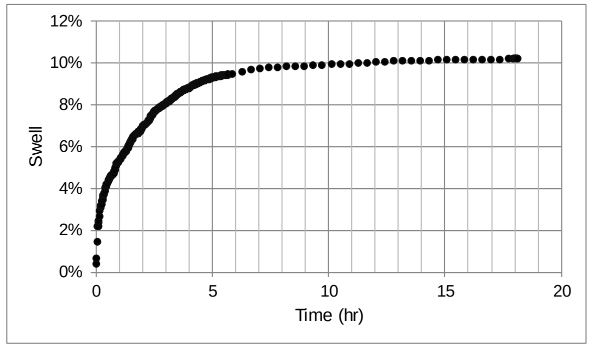
	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.022	cm
	Testing Height	0.996	0.997	cm
	Void Ratio, e	0.836	0.838	-
	Moisture Content	22.1%	31.8%	%
	Saturation	71.4%	100.0%	%
	Change in Moisture Content	-	9.6%	%
	Overburden Mass	-	141.99	g
	Height of Water	2.62	-	cm
	Primary Swell	-	0.1%	%
	Ultimate Swell	-	0.1%	%

NOTES	0.5' - 4' 4% HL



Primary Swell (%)	0.1%		Ultimate Swell (%)	0.1%
Slope of Primary Swelling	0.13%	% per log cycle	Time to Swell (hr)	0.33
Slope of Secondary Swelling	-0.05%	% per log cycle	Stress (psf)	285

Date test conducted	7/31/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly



SOIL Information

Soil	US 87
Target Water Content	24%
Water Content	21%
Specific Gravity	2.70

TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	30.00	33.70	gravity
Initial Moisture Content	24.0%	21.1%	%
Mass Soil Added	37.70	37.56	g
Dry Unit Weight	14.89	15.44	kN/m3
Height of Sample	1.000	0.989	cm

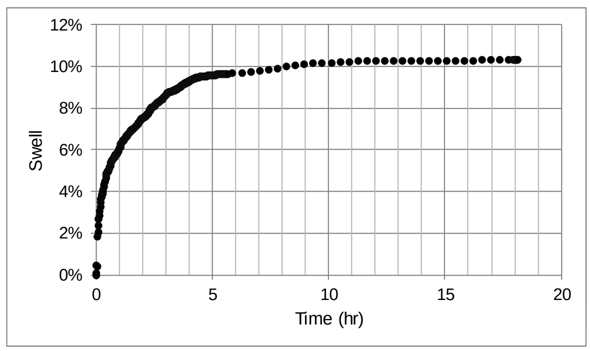
TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	-0.026	cm
Testing Height	0.973	1.072	cm
Void Ratio, e	0.716	0.891	-
Moisture Content	21.1%	36.9%	%
Saturation	79.5%	100.0%	%
Change in Moisture Content	-	15.8%	%
Overburden Mass	-	40.31	g
Height of Water	2.44	-	cm
Primary Swell	-	9.6%	%
Ultimate Swell	-	10.2%	%

Primary Swell (%)	9.6%	
Ultimate Swell (%)	10.2%	
Slope of Primary Swelling	5.36%	% per log cycle
Time to Swell (hr)	6.27	
Slope of Secondary Swelling	1.07%	% per log cycle
Stress (psf)	195	

NOTES: 4' - 6' Depth

Date test conducted	7/31/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly



SOIL Information

Soil	US 87
Target Water Content	24%
Water Content	21%
Specific Gravity	2.70

TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	30.00	33.70	gravity
Initial Moisture Content	24.0%	21.2%	%
Mass Soil Added	37.70	37.58	g
Dry Unit Weight	14.79	15.34	kN/m3
Height of Sample	1.000	0.995	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	-0.019	cm
Testing Height	0.978	1.079	cm
Void Ratio, e	0.726	0.905	-
Moisture Content	21.2%	37.5%	%
Saturation	78.9%	100.0%	%
Change in Moisture Content	-	16.3%	%
Overburden Mass	-	40.57	g
Height of Water	2.44	-	cm
Primary Swell	-	9.7%	%
Ultimate Swell	-	10.3%	%

Primary Swell (%)	9.7%	
Ultimate Swell (%)	10.3%	
Slope of Primary Swelling	4.72%	% per log cycle
Time to Swell (hr)	6.65	
Slope of Secondary Swelling	0.65%	% per log cycle
Stress (psf)	196	

NOTES: 4' - 6' Depth

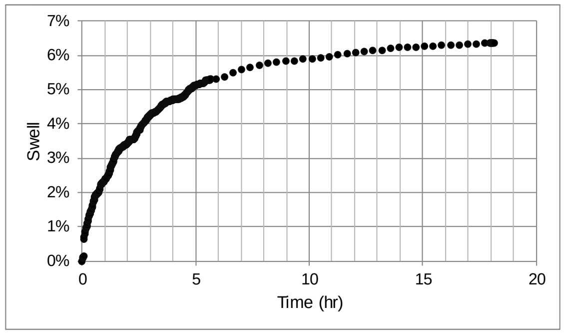
Date test conducted	7/31/2017
Centrifuge used	2
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	33.70	gravity
	Initial Moisture Content	24.0%	22.3%	%
	Mass Soil Added	37.69	37.57	g
	Dry Unit Weight	14.85	14.92	kN/m3
	Height of Sample	1.000	0.991	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.000	cm
	Testing Height	0.996	1.060	cm
	Void Ratio, e	0.775	0.888	-
	Moisture Content	22.3%	35.6%	%
	Saturation	77.8%	100.0%	%
	Change in Moisture Content	-	13.2%	%
	Overburden Mass	-	72.51	g
	Height of Water	2.43	-	cm
	Primary Swell	-	5.8%	%
	Ultimate Swell	-	6.4%	%

NOTES	4' - 6' Depth



Primary Swell (%)	5.8%	
Slope of Primary Swelling	3.58%	% per log cycle
Slope of Secondary Swelling	1.79%	% per log cycle

Ultimate Swell (%)	6.4%
Time to Swell (hr)	8.18
Stress (psf)	300

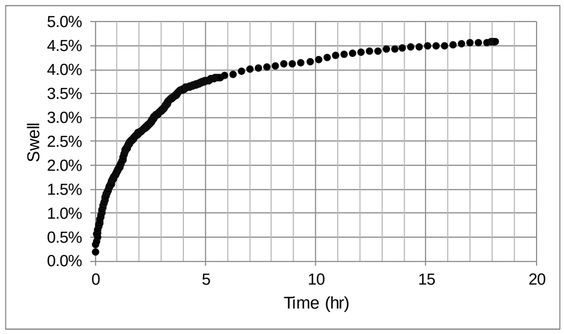
Date test conducted	7/31/2017
Centrifuge used	2
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	24%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	33.70	gravity
	Initial Moisture Content	24.0%	22.3%	%
	Mass Soil Added	37.71	37.61	g
	Dry Unit Weight	14.73	15.10	kN/m3
	Height of Sample	1.000	0.999	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.010	cm
	Testing Height	0.986	1.031	cm
	Void Ratio, e	0.754	0.835	-
	Moisture Content	22.3%	35.2%	%
	Saturation	79.7%	100.0%	%
	Change in Moisture Content	-	12.9%	%
	Overburden Mass	-	73.70	g
	Height of Water	2.45	-	cm
	Primary Swell	-	3.7%	%
	Ultimate Swell	-	4.6%	%

NOTES	4' - 6' Depth



Primary Swell (%)	3.7%	
Slope of Primary Swelling	2.70%	% per log cycle
Slope of Secondary Swelling	1.47%	% per log cycle

Ultimate Swell (%)	4.6%
Time to Swell (hr)	4.40
Stress (psf)	303

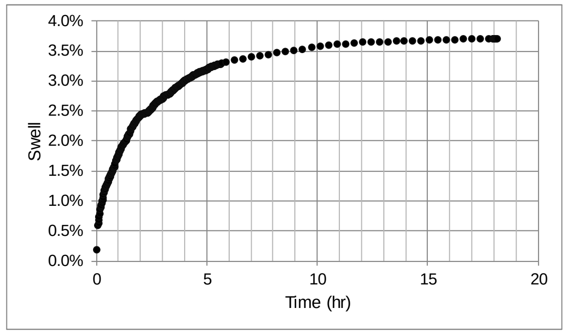
Date test conducted	7/31/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	33.70	gravity
	Initial Moisture Content	24.0%	22.6%	%
	Mass Soil Added	37.70	37.51	g
	Dry Unit Weight	14.75	14.72	kN/m3
	Height of Sample	1.000	0.998	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.001	cm
	Testing Height	1.006	1.043	cm
	Void Ratio, e	0.800	0.867	-
	Moisture Content	22.6%	34.5%	%
	Saturation	76.4%	100.0%	%
	Change in Moisture Content	-	11.9%	%
	Overburden Mass	-	139.66	g
	Height of Water	2.45	-	cm
	Primary Swell	-	3.4%	%
	Ultimate Swell	-	3.7%	%

NOTES	4' - 6' Depth



Primary Swell (%)	3.4%	
Slope of Primary Swelling	1.92%	% per log cycle
Slope of Secondary Swelling	0.65%	% per log cycle

Ultimate Swell (%)	3.7%
Time to Swell (hr)	7.41
Stress (psf)	519

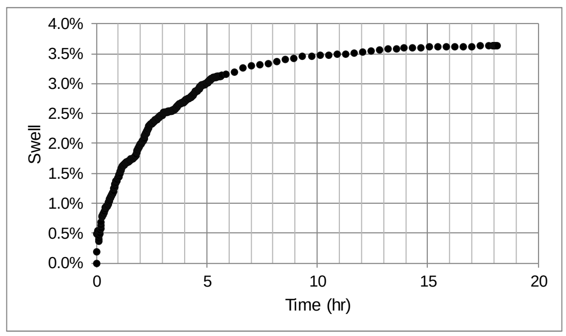
Date test conducted	7/31/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	US 87
	Target Water Content	24%
	Water Content	23%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	33.70	gravity
	Initial Moisture Content	24.0%	22.7%	%
	Mass Soil Added	37.72	37.64	g
	Dry Unit Weight	14.81	15.10	kN/m3
	Height of Sample	1.000	0.994	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.024	cm
	Testing Height	0.983	1.019	cm
	Void Ratio, e	0.754	0.818	-
	Moisture Content	22.7%	34.8%	%
	Saturation	81.4%	100.0%	%
	Change in Moisture Content	-	12.1%	%
	Overburden Mass	-	141.90	g
	Height of Water	2.44	-	cm
	Primary Swell	-	3.4%	%
	Ultimate Swell	-	3.6%	%

NOTES	4' - 6' Depth



Primary Swell (%)	3.4%	
Slope of Primary Swelling	2.13%	% per log cycle
Slope of Secondary Swelling	0.67%	% per log cycle

Ultimate Swell (%)	3.6%
Time to Swell (hr)	8.18
Stress (psf)	526

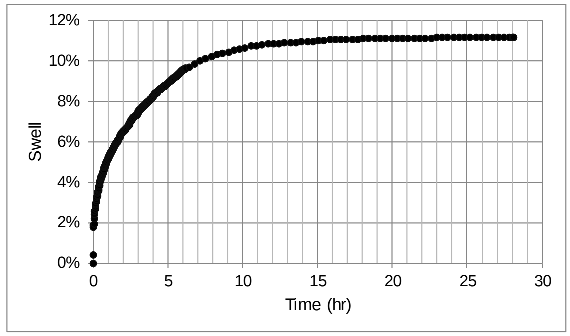
Date test conducted	8/2/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	23%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	27.27	gravity
	Initial Moisture Content	23.0%	21.3%	%
	Mass Soil Added	37.54	37.41	g
	Dry Unit Weight	14.75	15.05	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.073	cm
	Testing Height	0.991	1.102	cm
	Void Ratio, e	0.760	0.956	-
	Moisture Content	21.3%	40.4%	%
	Saturation	75.9%	100.0%	%
	Change in Moisture Content	-	19.0%	%
	Overburden Mass	-	40.33	g
	Height of Water	2.42	-	cm
	Primary Swell	-	10.9%	%
	Ultimate Swell	-	11.2%	%

NOTES	6' - 10' Depth



Primary Swell (%)	10.9%	Ultimate Swell (%)	11.2%
Slope of Primary Swelling	5.02% % per log cycle	Time to Swell (hr)	13.57
Slope of Secondary Swelling	0.83% % per log cycle	Stress (psf)	158

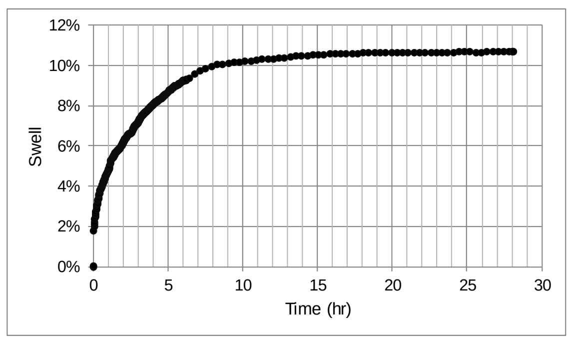
Date test conducted	8/2/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	23%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	27.27	gravity
	Initial Moisture Content	23.0%	21.9%	%
	Mass Soil Added	37.50	37.30	g
	Dry Unit Weight	14.81	13.78	kN/m3
	Height of Sample	1.000	0.996	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.603	cm
	Testing Height	1.075	1.190	cm
	Void Ratio, e	0.922	1.128	-
	Moisture Content	21.9%	39.4%	%
	Saturation	64.1%	94.3%	%
	Change in Moisture Content	-	17.5%	%
	Overburden Mass	-	40.92	g
	Height of Water	2.42	-	cm
	Primary Swell	-	10.3%	%
	Ultimate Swell	-	10.7%	%

NOTES	6' - 10' Depth



Primary Swell (%)	10.3%	Ultimate Swell (%)	10.7%
Slope of Primary Swelling	5.23% % per log cycle	Time to Swell (hr)	11.31
Slope of Secondary Swelling	0.80% % per log cycle	Stress (psf)	161

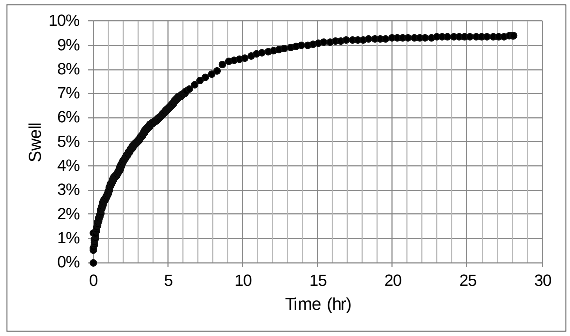
Date test conducted	8/2/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	23%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	27.27	gravity
	Initial Moisture Content	23.0%	22.4%	%
	Mass Soil Added	37.50	37.40	g
	Dry Unit Weight	14.91	15.16	kN/m3
	Height of Sample	1.000	0.990	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.039	cm
	Testing Height	0.975	1.067	cm
	Void Ratio, e	0.747	0.911	-
	Moisture Content	22.4%	38.7%	%
	Saturation	81.0%	100.0%	%
	Change in Moisture Content	-	16.3%	%
	Overburden Mass	-	73.67	g
	Height of Water	2.45	-	cm
	Primary Swell	-	9.4%	%
	Ultimate Swell	-	9.4%	%

NOTES	6' - 10' Depth



Primary Swell (%)	9.4%	
Ultimate Swell (%)	9.4%	
Slope of Primary Swelling	4.52%	% per log cycle
Time to Swell (hr)	24.09	
Slope of Secondary Swelling	1.43%	% per log cycle
Stress (psf)	246	

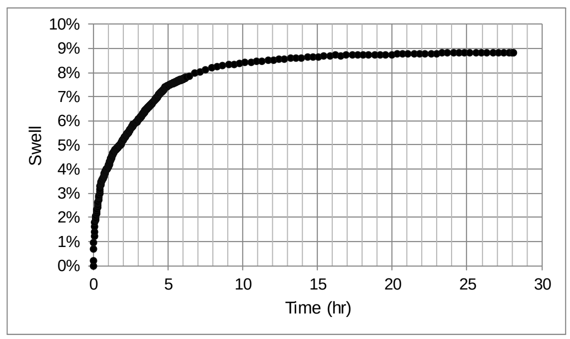
Date test conducted	8/2/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	23%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	27.27	gravity
	Initial Moisture Content	23.0%	22.0%	%
	Mass Soil Added	37.50	37.38	g
	Dry Unit Weight	14.76	15.02	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.060	cm
	Testing Height	0.987	1.074	cm
	Void Ratio, e	0.764	0.920	-
	Moisture Content	22.0%	39.8%	%
	Saturation	77.9%	100.0%	%
	Change in Moisture Content	-	17.7%	%
	Overburden Mass	-	75.64	g
	Height of Water	2.42	-	cm
	Primary Swell	-	8.4%	%
	Ultimate Swell	-	8.8%	%

NOTES	6' - 10' Depth



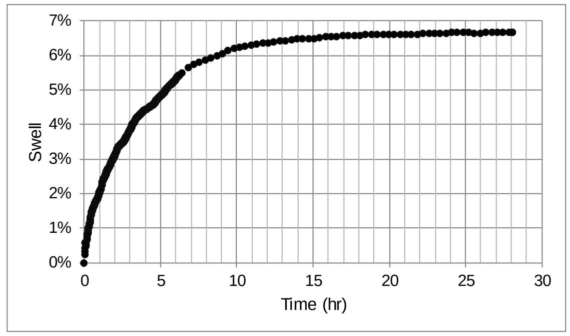
Primary Swell (%)	8.4%	
Ultimate Swell (%)	8.8%	
Slope of Primary Swelling	4.21%	% per log cycle
Time to Swell (hr)	10.18	
Slope of Secondary Swelling	0.75%	% per log cycle
Stress (psf)	251	

	Date test conducted	8/2/2017
	Centrifuge used	3
	Cup Number	5
	Conducted by	Karly
SOIL Information	Soil	US 87
	Target Water Content	23%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	27.27	gravity
	Initial Moisture Content	23.0%	22.1%	%
	Mass Soil Added	37.51	37.35	g
	Dry Unit Weight	14.76	14.97	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.048	cm
	Testing Height	0.989	1.055	cm
	Void Ratio, e	0.769	0.887	-
	Moisture Content	22.1%	37.3%	%
	Saturation	77.7%	100.0%	%
	Change in Moisture Content	-	15.1%	%
	Overburden Mass	-	141.82	g
	Height of Water	2.45	-	cm
	Primary Swell	-	6.4%	%
	Ultimate Swell	-	6.7%	%

NOTES	6' - 10' Depth



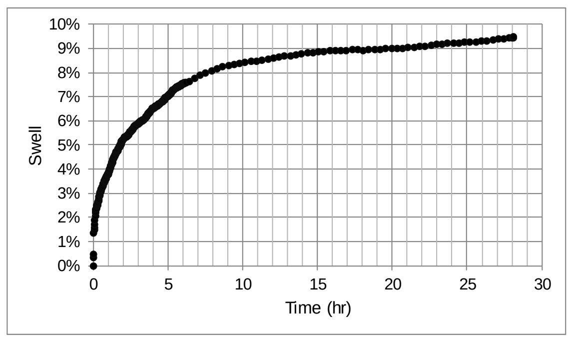
Primary Swell (%)	6.4%		Ultimate Swell (%)	6.7%
Slope of Primary Swelling	4.10%	% per log cycle	Time to Swell (hr)	12.44
Slope of Secondary Swelling	0.69%	% per log cycle	Stress (psf)	426

	Date test conducted	8/2/2017
	Centrifuge used	3
	Cup Number	6
	Conducted by	Karly
SOIL Information	Soil	US 87
	Target Water Content	23%
	Water Content	22%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	27.27	gravity
	Initial Moisture Content	23.0%	22.4%	%
	Mass Soil Added	37.51	37.41	g
	Dry Unit Weight	14.81	14.97	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.034	cm
	Testing Height	0.988	1.081	cm
	Void Ratio, e	0.769	0.936	-
	Moisture Content	22.4%	37.6%	%
	Saturation	78.7%	100.0%	%
	Change in Moisture Content	-	15.2%	%
	Overburden Mass	-	140.59	g
	Height of Water	2.44	-	cm
	Primary Swell	-	8.4%	%
	Ultimate Swell	-	9.5%	%

NOTES	6' - 10' Depth



Primary Swell (%)	8.4%		Ultimate Swell (%)	9.5%
Slope of Primary Swelling	4.61%	% per log cycle	Time to Swell (hr)	10.18
Slope of Secondary Swelling	2.28%	% per log cycle	Stress (psf)	422

APPENDIX E: US 87 B-04 CENTRIFUGE TEST RESULTS

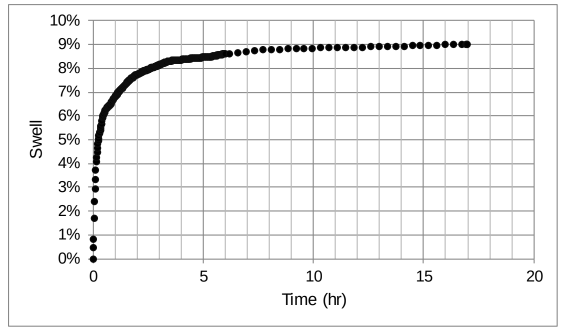
Date test conducted	7/31/2017	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.79	gravity
	Initial Moisture Content	22.0%	21.3%	%
	Mass Soil Added	37.84	37.77	g
	Dry Unit Weight	15.02	15.27	kN/m3
	Height of Sample	1.000	0.999	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.001	cm
	Testing Height	0.987	1.076	cm
	Void Ratio, e	0.735	0.891	-
	Moisture Content	21.3%	37.2%	%
	Saturation	78.3%	100.0%	%
	Change in Moisture Content	-	15.9%	%
	Overburden Mass	-	40.58	g
	Height of Water	2.43	-	cm
	Primary Swell	-	8.4%	%
	Ultimate Swell	-	9.0%	%

NOTES	0' - 2' Depth



Primary Swell (%)	8.4%		Ultimate Swell (%)	9.0%
Slope of Primary Swelling	2.67%	% per log cycle	Time to Swell (hr)	4.63
Slope of Secondary Swelling	0.65%	% per log cycle	Stress (psf)	144

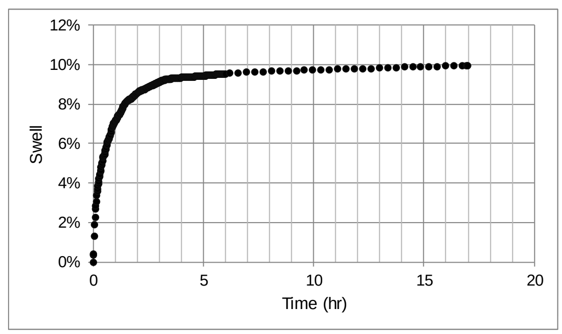
Date test conducted	7/31/2017	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.79	gravity
	Initial Moisture Content	22.0%	21.6%	%
	Mass Soil Added	37.87	37.78	g
	Dry Unit Weight	15.16	14.42	kN/m3
	Height of Sample	1.000	0.991	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	0.814	cm
	Testing Height	1.043	1.146	cm
	Void Ratio, e	0.837	1.020	-
	Moisture Content	21.6%	37.3%	%
	Saturation	69.8%	98.7%	%
	Change in Moisture Content	-	15.6%	%
	Overburden Mass	-	41.23	g
	Height of Water	2.43	-	cm
	Primary Swell	-	8.9%	%
	Ultimate Swell	-	10.0%	%

NOTES	0' - 2' Depth



Primary Swell (%)	8.9%		Ultimate Swell (%)	10.0%
Slope of Primary Swelling	5.15%	% per log cycle	Time to Swell (hr)	2.63
Slope of Secondary Swelling	0.97%	% per log cycle	Stress (psf)	147

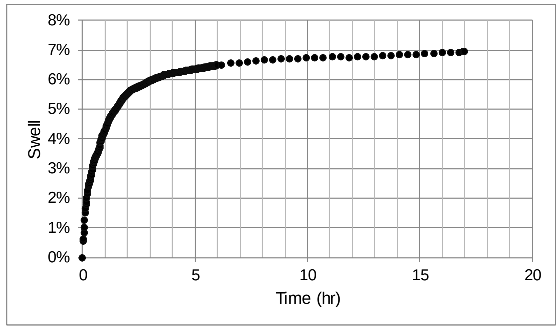
Date test conducted	7/31/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.79	gravity
	Initial Moisture Content	22.0%	22.0%	%
	Mass Soil Added	37.84	37.76	g
	Dry Unit Weight	15.05	15.19	kN/m3
	Height of Sample	1.000	0.997	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.040	cm
	Testing Height	0.987	1.055	cm
	Void Ratio, e	0.744	0.865	-
	Moisture Content	22.0%	35.4%	%
	Saturation	79.7%	100.0%	%
	Change in Moisture Content	-	13.4%	%
	Overburden Mass	-	73.44	g
	Height of Water	2.44	-	cm
	Primary Swell	-	6.2%	%
	Ultimate Swell	-	6.9%	%

NOTES	0' - 2' Depth



Primary Swell (%)	6.2%		Ultimate Swell (%)	6.9%
Slope of Primary Swelling	3.68%	% per log cycle	Time to Swell (hr)	3.86
Slope of Secondary Swelling	0.87%	% per log cycle	Stress (psf)	223

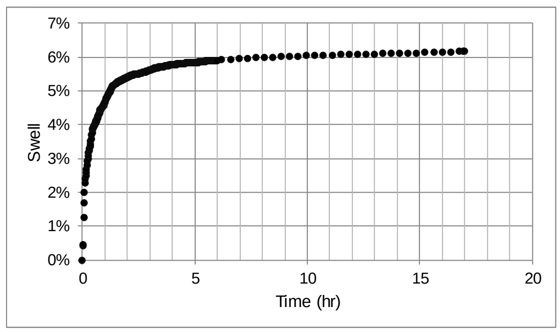
Date test conducted	7/31/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.79	gravity
	Initial Moisture Content	22.0%	21.5%	%
	Mass Soil Added	37.87	37.77	g
	Dry Unit Weight	15.01	15.23	kN/m3
	Height of Sample	1.000	1.001	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.047	cm
	Testing Height	0.988	1.049	cm
	Void Ratio, e	0.740	0.847	-
	Moisture Content	21.5%	35.2%	%
	Saturation	78.4%	100.0%	%
	Change in Moisture Content	-	13.7%	%
	Overburden Mass	-	73.53	g
	Height of Water	2.41	-	cm
	Primary Swell	-	5.5%	%
	Ultimate Swell	-	6.2%	%

NOTES	0' - 2' Depth



Primary Swell (%)	5.5%		Ultimate Swell (%)	6.2%
Slope of Primary Swelling	2.53%	% per log cycle	Time to Swell (hr)	2.63
Slope of Secondary Swelling	0.58%	% per log cycle	Stress (psf)	223

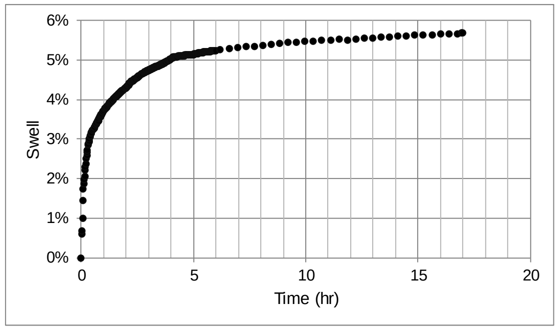
Date test conducted	7/31/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.79	gravity
	Initial Moisture Content	22.0%	22.1%	%
	Mass Soil Added	37.84	37.78	g
	Dry Unit Weight	15.02	15.11	kN/m3
	Height of Sample	1.000	1.000	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.047	cm
	Testing Height	0.991	1.047	cm
	Void Ratio, e	0.753	0.852	-
	Moisture Content	22.1%	35.5%	%
	Saturation	79.4%	100.0%	%
	Change in Moisture Content	-	13.4%	%
	Overburden Mass	-	141.32	g
	Height of Water	2.42	-	cm
	Primary Swell	-	5.2%	%
	Ultimate Swell	-	5.7%	%

NOTES	0' - 2' Depth



Primary Swell (%)	5.2%	
Slope of Primary Swelling	2.05%	% per log cycle
Slope of Secondary Swelling	0.90%	% per log cycle

Ultimate Swell (%)	5.7%
Time to Swell (hr)	5.04
Stress (psf)	386

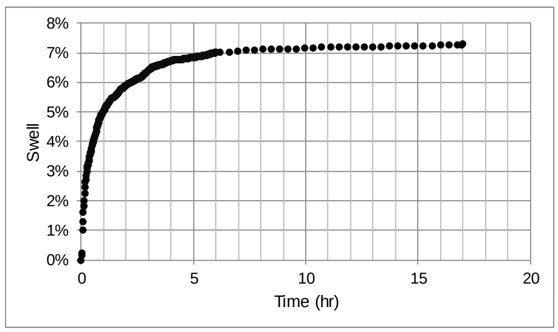
Date test conducted	7/31/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	22%
	Specific Gravity	2.70

	Property	Target	Actual	Unit
TESTING SETUP Information	G-Level	30.00	24.79	gravity
	Initial Moisture Content	22.0%	22.3%	%
	Mass Soil Added	37.87	37.85	g
	Dry Unit Weight	15.13	15.15	kN/m3
	Height of Sample	1.000	0.993	cm

	Property	Initial	Final	Unit
TEST RESULTS Information	Seating Height	-	-0.053	cm
	Testing Height	0.988	1.061	cm
	Void Ratio, e	0.748	0.876	-
	Moisture Content	22.3%	34.7%	%
	Saturation	80.6%	100.0%	%
	Change in Moisture Content	-	12.4%	%
	Overburden Mass	-	140.79	g
	Height of Water	2.44	-	cm
	Primary Swell	-	6.8%	%
	Ultimate Swell	-	7.3%	%

NOTES	0' - 2' Depth



Primary Swell (%)	6.8%	
Slope of Primary Swelling	3.18%	% per log cycle
Slope of Secondary Swelling	0.58%	% per log cycle

Ultimate Swell (%)	7.3%
Time to Swell (hr)	4.46
Stress (psf)	385

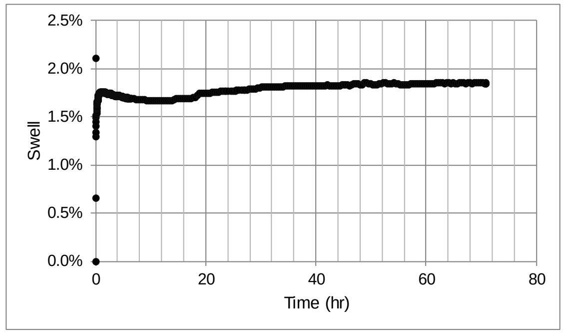
Date test conducted	8/14/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	4% HL
	Target Water Content	22%
	Water Content	19%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	29.62	gravity
	Initial Moisture Content	22.0%	18.9%	%
	Mass Soil Added	37.83	37.67	g
	Dry Unit Weight	15.05	15.39	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.068	cm
	Testing Height	0.996	1.015	cm
	Void Ratio, e	0.722	0.754	-
	Moisture Content	18.9%	28.7%	%
	Saturation	70.9%	100.0%	%
	Change in Moisture Content	-	9.8%	%
	Overburden Mass	-	39.33	g
	Height of Water	2.44	-	cm
	Primary Swell	-	1.8%	%
	Ultimate Swell	-	1.9%	%

NOTES	US 87 0' - 2' Depth, 4% HL



Primary Swell (%)	1.8%	
Slope of Primary Swelling	0.72%	% per log cycle
Slope of Secondary Swelling	-0.13%	% per log cycle

Ultimate Swell (%)	1.9%
Time to Swell (hr)	0.79
Stress (psf)	168

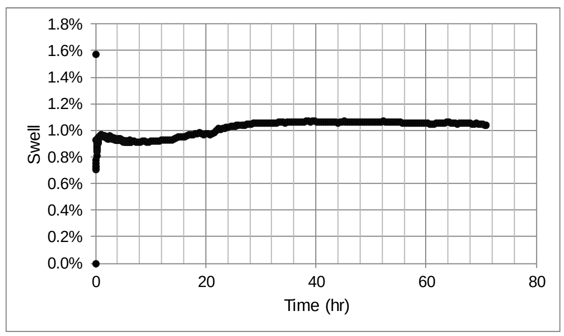
Date test conducted	8/14/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	4% HL
	Target Water Content	22%
	Water Content	19%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	29.62	gravity
	Initial Moisture Content	22.0%	19.3%	%
	Mass Soil Added	37.84	37.73	gravity
	Dry Unit Weight	14.99	15.46	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.040	cm
	Testing Height	0.990	1.001	cm
	Void Ratio, e	0.713	0.731	-
	Moisture Content	19.3%	29.8%	%
	Saturation	73.0%	100.0%	%
	Change in Moisture Content	-	10.5%	%
	Overburden Mass	-	41.16	g
	Height of Water	2.44	-	cm
	Primary Swell	-	1.0%	%
	Ultimate Swell	-	1.1%	%

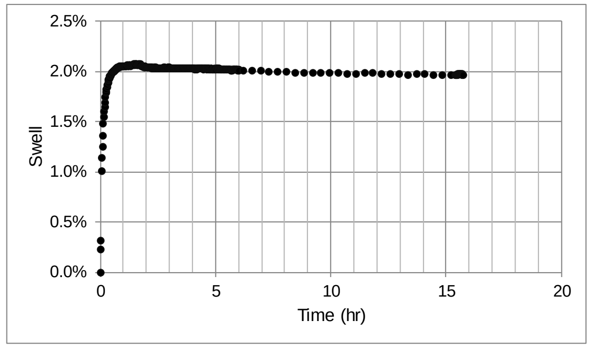
NOTES	US 87 0' - 2' Depth, 4% HL



Primary Swell (%)	1.0%	
Slope of Primary Swelling	0.28%	% per log cycle
Slope of Secondary Swelling	-0.06%	% per log cycle

Ultimate Swell (%)	1.1%
Time to Swell (hr)	0.74
Stress (psf)	173

Date test conducted	8/14/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly



SOIL Information

Soil	4% HL
Target Water Content	20%
Water Content	19%
Specific Gravity	2.70

TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	30.00	28.42	gravity
Initial Moisture Content	20.0%	19.3%	%
Mass Soil Added	37.81	37.69	g
Dry Unit Weight	15.35	15.40	kN/m3
Height of Sample	1.000	0.994	cm

TEST RESULTS Information

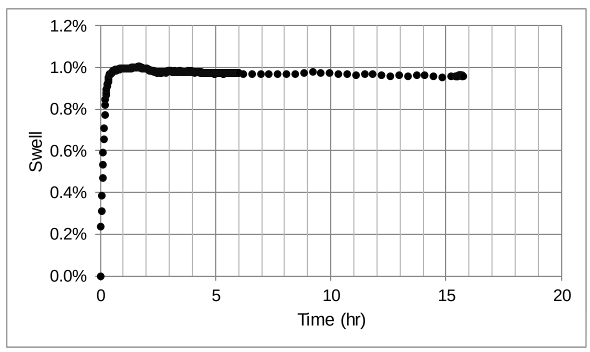
Property	Initial	Final	Unit
Seating Height	-	-0.032	cm
Testing Height	0.993	1.013	cm
Void Ratio, e	0.720	0.756	-
Moisture Content	19.3%	28.5%	%
Saturation	72.6%	100.0%	%
Change in Moisture Content	-	9.2%	%
Overburden Mass	-	142.60	g
Height of Water	2.44	-	cm
Primary Swell	-	2.0%	%
Ultimate Swell	-	2.1%	%

Primary Swell (%)	2.0%	
Ultimate Swell (%)	2.1%	
Slope of Primary Swelling	1.17%	% per log cycle
Time to Swell (hr)	0.52	
Slope of Secondary Swelling	-0.10%	% per log cycle
Stress (psf)	446	

NOTES

US 87 0' - 2' Depth, 4% HL

Date test conducted	8/14/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly



SOIL Information

Soil	4% HL
Target Water Content	20%
Water Content	19%
Specific Gravity	2.70

TESTING SETUP Information

Property	Target	Actual	Unit
G-Level	30.00	28.42	gravity
Initial Moisture Content	20.0%	19.4%	%
Mass Soil Added	37.80	37.68	g
Dry Unit Weight	15.37	15.42	kN/m3
Height of Sample	1.000	0.992	cm

TEST RESULTS Information

Property	Initial	Final	Unit
Seating Height	-	1.656	cm
Testing Height	0.991	1.001	cm
Void Ratio, e	0.718	0.735	-
Moisture Content	19.4%	28.5%	%
Saturation	72.8%	100.0%	%
Change in Moisture Content	-	9.2%	%
Overburden Mass	-	141.30	g
Height of Water	2.43	-	cm
Primary Swell	-	1.0%	%
Ultimate Swell	-	1.0%	%

Primary Swell (%)	1.0%	
Ultimate Swell (%)	1.0%	
Slope of Primary Swelling	0.90%	% per log cycle
Time to Swell (hr)	0.39	
Slope of Secondary Swelling	-0.03%	% per log cycle
Stress (psf)	443	

NOTES

US 87 0' - 2' Depth, 4% HL

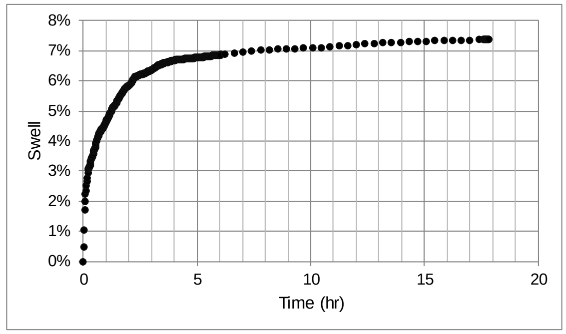
Date test conducted	8/1/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	34.84	gravity
	Initial Moisture Content	21.5%	21.4%	%
	Mass Soil Added	37.75	37.64	g
	Dry Unit Weight	15.06	15.14	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.042	cm
	Testing Height	0.991	1.064	cm
	Void Ratio, e	0.750	0.879	-
	Moisture Content	21.4%	36.9%	%
	Saturation	77.1%	100.0%	%
	Change in Moisture Content	-	15.5%	%
	Overburden Mass	-	39.99	g
	Height of Water	2.39	-	cm
	Primary Swell	-	6.3%	%
	Ultimate Swell	-	7.4%	%

NOTES	2' - 4' Depth



Primary Swell (%)	6.3%	Ultimate Swell (%)	7.4%
Slope of Primary Swelling	4.05% % per log cycle	Time to Swell (hr)	2.94
Slope of Secondary Swelling	1.08% % per log cycle	Stress (psf)	200

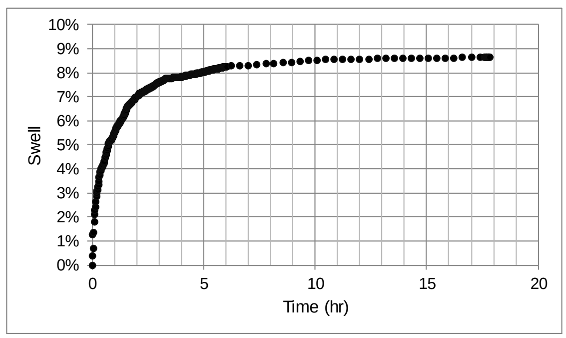
Date test conducted	8/1/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	34.84	gravity
	Initial Moisture Content	21.5%	21.4%	%
	Mass Soil Added	37.70	37.60	g
	Dry Unit Weight	15.04	15.28	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.061	cm
	Testing Height	0.981	1.066	cm
	Void Ratio, e	0.734	0.884	-
	Moisture Content	21.4%	37.6%	%
	Saturation	78.8%	100.0%	%
	Change in Moisture Content	-	16.1%	%
	Overburden Mass	-	40.90	g
	Height of Water	2.43	-	cm
	Primary Swell	-	7.4%	%
	Ultimate Swell	-	8.7%	%

NOTES	2' - 4' Depth



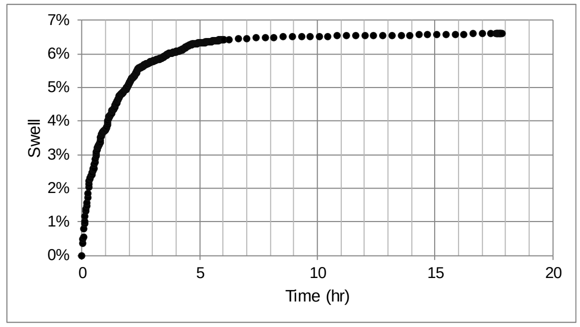
Primary Swell (%)	7.4%	Ultimate Swell (%)	8.7%
Slope of Primary Swelling	5.06% % per log cycle	Time to Swell (hr)	2.61
Slope of Secondary Swelling	1.28% % per log cycle	Stress (psf)	203

	Date test conducted	8/1/2017
	Centrifuge used	2
	Cup Number	3
	Conducted by	Karly
SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	34.84	gravity
	Initial Moisture Content	21.5%	21.1%	%
	Mass Soil Added	37.71	37.64	g
	Dry Unit Weight	15.05	15.17	kN/m3
	Height of Sample	1.000	0.998	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.032	cm
	Testing Height	0.992	1.057	cm
	Void Ratio, e	0.746	0.862	-
	Moisture Content	21.1%	35.6%	%
	Saturation	76.4%	100.0%	%
	Change in Moisture Content	-	14.5%	%
	Overburden Mass	-	73.74	g
	Height of Water	2.44	-	cm
	Primary Swell	-	6.3%	%
	Ultimate Swell	-	6.6%	%

NOTES	2' - 4' Depth



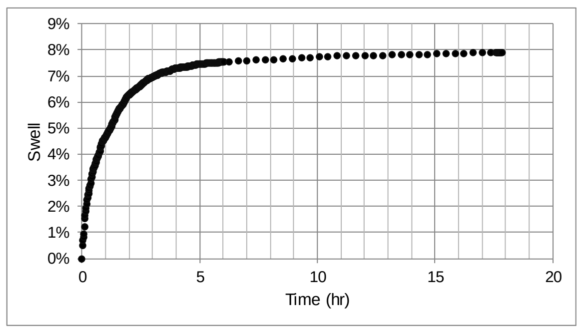
Primary Swell (%)	6.3%		Ultimate Swell (%)	6.6%
Slope of Primary Swelling	3.25%	% per log cycle	Time to Swell (hr)	4.59
Slope of Secondary Swelling	0.36%	% per log cycle	Stress (psf)	315

	Date test conducted	8/1/2017
	Centrifuge used	2
	Cup Number	4
	Conducted by	Karly
SOIL Information	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	34.84	gravity
	Initial Moisture Content	21.5%	21.4%	%
	Mass Soil Added	37.72	37.65	g
	Dry Unit Weight	15.07	15.22	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.041	cm
	Testing Height	0.986	1.064	cm
	Void Ratio, e	0.741	0.878	-
	Moisture Content	21.4%	36.2%	%
	Saturation	78.1%	100.0%	%
	Change in Moisture Content	-	14.8%	%
	Overburden Mass	-	73.65	g
	Height of Water	2.46	-	cm
	Primary Swell	-	7.3%	%
	Ultimate Swell	-	7.9%	%

NOTES	2' - 4' Depth



Primary Swell (%)	7.3%		Ultimate Swell (%)	7.9%
Slope of Primary Swelling	3.85%	% per log cycle	Time to Swell (hr)	3.83
Slope of Secondary Swelling	0.80%	% per log cycle	Stress (psf)	315

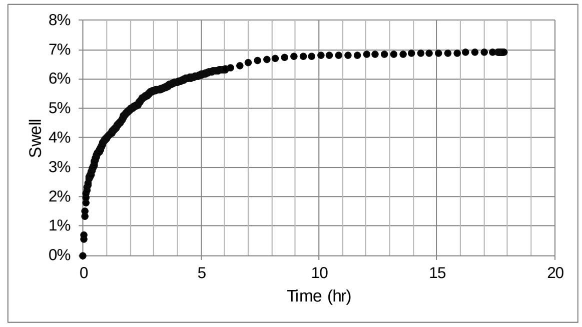
Date test conducted	8/1/2017
Centrifuge used	2
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	34.84	gravity
	Initial Moisture Content	21.5%	21.2%	%
	Mass Soil Added	37.71	37.69	g
	Dry Unit Weight	15.10	15.14	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.039	cm
	Testing Height	0.994	1.063	cm
	Void Ratio, e	0.750	0.871	-
	Moisture Content	21.2%	35.1%	%
	Saturation	76.3%	100.0%	%
	Change in Moisture Content	-	13.9%	%
	Overburden Mass	-	141.16	g
	Height of Water	2.41	-	cm
	Primary Swell	-	6.6%	%
	Ultimate Swell	-	6.9%	%

NOTES	2' - 4' Depth



Primary Swell (%)	6.6%		Ultimate Swell (%)	6.9%
Slope of Primary Swelling	3.07%	% per log cycle	Time to Swell (hr)	7.40
Slope of Secondary Swelling	0.50%	% per log cycle	Stress (psf)	542

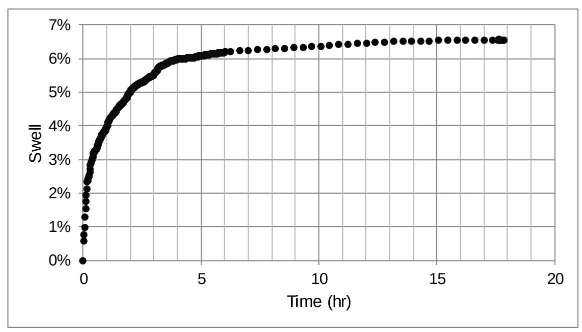
Date test conducted	8/1/2017
Centrifuge used	2
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	34.84	gravity
	Initial Moisture Content	21.5%	21.4%	%
	Mass Soil Added	37.70	37.66	g
	Dry Unit Weight	15.08	15.28	kN/m3
	Height of Sample	1.000	0.996	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.098	cm
	Testing Height	0.983	1.047	cm
	Void Ratio, e	0.734	0.848	-
	Moisture Content	21.4%	35.1%	%
	Saturation	78.9%	100.0%	%
	Change in Moisture Content	-	13.7%	%
	Overburden Mass	-	140.52	g
	Height of Water	2.43	-	cm
	Primary Swell	-	6.0%	%
	Ultimate Swell	-	6.6%	%

NOTES	2' - 4' Depth



Primary Swell (%)	6.0%		Ultimate Swell (%)	6.6%
Slope of Primary Swelling	3.50%	% per log cycle	Time to Swell (hr)	3.91
Slope of Secondary Swelling	0.81%	% per log cycle	Stress (psf)	540

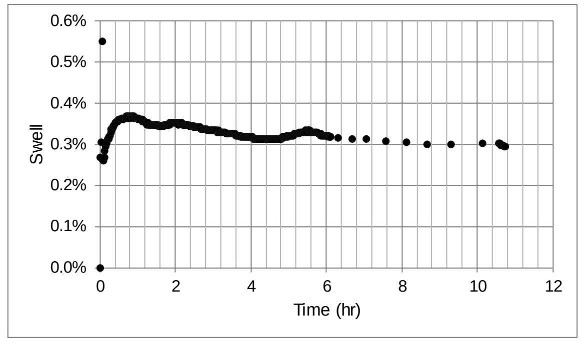
Date test conducted	8/17/2017
Centrifuge used	2
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	4% HL
	Target Water Content	21%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	36.95	gravity
	Initial Moisture Content	21.0%	21.1%	%
	Mass Soil Added	37.63	37.49	g
	Dry Unit Weight	15.03	14.98	kN/m3
	Height of Sample	1.000	1.001	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.047	cm
	Testing Height	1.000	1.004	cm
	Void Ratio, e	0.768	0.774	-
	Moisture Content	21.1%	30.5%	%
	Saturation	74.1%	100.0%	%
	Change in Moisture Content	-	9.5%	%
	Overburden Mass	-	140.10	g
	Height of Water	2.44	-	cm
	Primary Swell	-	0.4%	%
	Ultimate Swell	-	0.4%	%

NOTES	US 87 2' - 4' Depth, 4% HL



Primary Swell (%)	0.4%	Ultimate Swell (%)	0.4%
Slope of Primary Swelling	0.13% % per log cycle	Time to Swell (hr)	0.77
Slope of Secondary Swelling	-0.07% % per log cycle	Stress (psf)	571

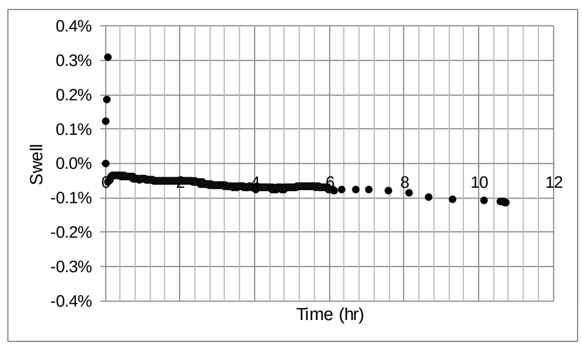
Date test conducted	8/17/2017
Centrifuge used	2
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	4% HL
	Target Water Content	21%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	36.95	gravity
	Initial Moisture Content	21.0%	21.1%	%
	Mass Soil Added	37.62	37.47	g
	Dry Unit Weight	15.14	15.07	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.083	cm
	Testing Height	0.994	0.993	cm
	Void Ratio, e	0.758	0.757	-
	Moisture Content	21.1%	29.3%	%
	Saturation	75.2%	100.0%	%
	Change in Moisture Content	-	8.2%	%
	Overburden Mass	-	139.96	g
	Height of Water	2.44	-	cm
	Primary Swell	-	0.0%	%
	Ultimate Swell	-	0.0%	%

NOTES	US 87 2' - 4' Depth, 4% HL



Primary Swell (%)	0.0%	Ultimate Swell (%)	0.0%
Slope of Primary Swelling	0.05% % per log cycle	Time to Swell (hr)	0.29
Slope of Secondary Swelling	-0.03% % per log cycle	Stress (psf)	570

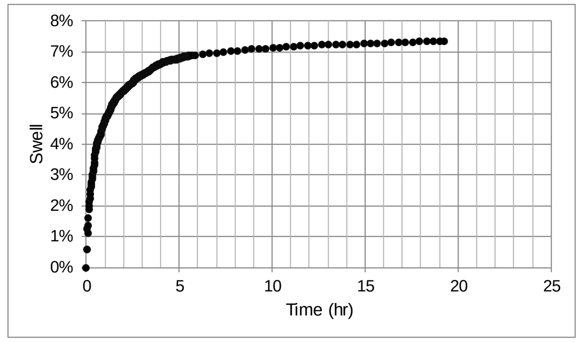
Date test conducted	8/1/2017	
Centrifuge used	3	
Cup Number	1	
Conducted by	Karly	

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	20%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.19	gravity
	Initial Moisture Content	22.0%	20.5%	%
	Mass Soil Added	37.69	37.57	g
	Dry Unit Weight	15.14	15.55	kN/m3
	Height of Sample	1.000	0.988	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.032	cm
	Testing Height	0.971	1.042	cm
	Void Ratio, e	0.704	0.829	-
	Moisture Content	20.5%	36.5%	%
	Saturation	78.5%	100.0%	%
	Change in Moisture Content	-	16.0%	%
	Overburden Mass	-	40.00	g
	Height of Water	2.46	-	cm
	Primary Swell	-	6.5%	%
	Ultimate Swell	-	7.3%	%

NOTES	4' - 6' Depth



Primary Swell (%)	6.5%		Ultimate Swell (%)	7.3%
Slope of Primary Swelling	3.49%	% per log cycle	Time to Swell (hr)	3.65
Slope of Secondary Swelling	0.90%	% per log cycle	Stress (psf)	185

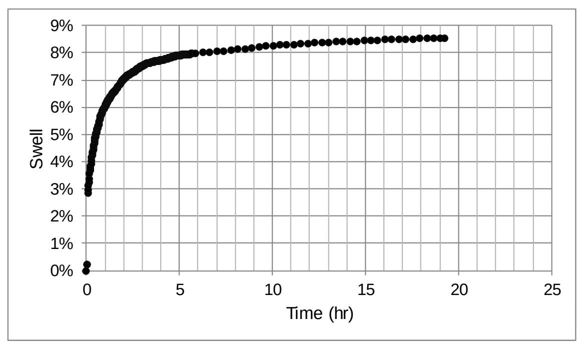
Date test conducted	8/1/2017	
Centrifuge used	3	
Cup Number	2	
Conducted by	Karly	

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.19	gravity
	Initial Moisture Content	22.0%	20.6%	%
	Mass Soil Added	37.75	37.59	g
	Dry Unit Weight	15.06	14.58	kN/m3
	Height of Sample	1.000	0.994	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	0.462	cm
	Testing Height	1.035	1.123	cm
	Void Ratio, e	0.816	0.971	-
	Moisture Content	20.6%	35.2%	%
	Saturation	68.0%	97.9%	%
	Change in Moisture Content	-	14.7%	%
	Overburden Mass	-	39.89	g
	Height of Water	2.43	-	cm
	Primary Swell	-	7.6%	%
	Ultimate Swell	-	8.5%	%

NOTES	4' - 6' Depth



Primary Swell (%)	7.6%		Ultimate Swell (%)	8.5%
Slope of Primary Swelling	3.29%	% per log cycle	Time to Swell (hr)	3.14
Slope of Secondary Swelling	1.19%	% per log cycle	Stress (psf)	186

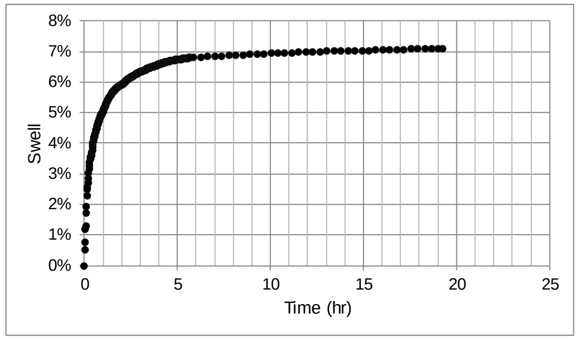
Date test conducted	8/1/2017
Centrifuge used	3
Cup Number	3
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.19	gravity
	Initial Moisture Content	22.0%	20.7%	%
	Mass Soil Added	37.76	37.68	g
	Dry Unit Weight	15.05	15.45	kN/m3
	Height of Sample	1.000	0.995	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.054	cm
	Testing Height	0.979	1.048	cm
	Void Ratio, e	0.715	0.837	-
	Moisture Content	20.7%	35.1%	%
	Saturation	78.0%	100.0%	%
	Change in Moisture Content	-	14.4%	%
	Overburden Mass	-	73.68	g
	Height of Water	2.45	-	cm
	Primary Swell	-	6.4%	%
	Ultimate Swell	-	7.1%	%

NOTES	4' - 6' Depth



Primary Swell (%)	6.4%		Ultimate Swell (%)	7.1%
Slope of Primary Swelling	3.24%	% per log cycle	Time to Swell (hr)	3.12
Slope of Secondary Swelling	0.59%	% per log cycle	Stress (psf)	291

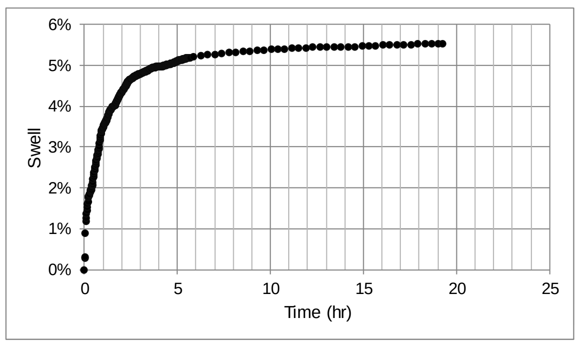
Date test conducted	8/1/2017
Centrifuge used	3
Cup Number	4
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.19	gravity
	Initial Moisture Content	22.0%	20.6%	%
	Mass Soil Added	37.70	37.63	g
	Dry Unit Weight	14.96	15.25	kN/m3
	Height of Sample	1.000	1.000	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.009	cm
	Testing Height	0.990	1.045	cm
	Void Ratio, e	0.736	0.832	-
	Moisture Content	20.6%	35.2%	%
	Saturation	75.4%	100.0%	%
	Change in Moisture Content	-	14.7%	%
	Overburden Mass	-	74.17	g
	Height of Water	2.43	-	cm
	Primary Swell	-	5.0%	%
	Ultimate Swell	-	5.5%	%

NOTES	4' - 6' Depth



Primary Swell (%)	5.0%		Ultimate Swell (%)	5.5%
Slope of Primary Swelling	2.55%	% per log cycle	Time to Swell (hr)	4.48
Slope of Secondary Swelling	0.62%	% per log cycle	Stress (psf)	292

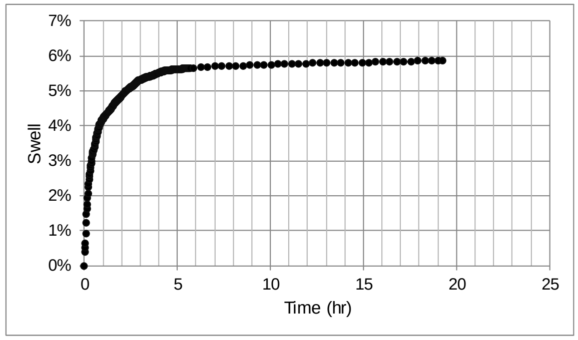
Date test conducted	8/1/2017
Centrifuge used	3
Cup Number	5
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.19	gravity
	Initial Moisture Content	22.0%	20.9%	%
	Mass Soil Added	37.74	37.69	g
	Dry Unit Weight	15.02	15.42	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.045	cm
	Testing Height	0.978	1.035	cm
	Void Ratio, e	0.717	0.818	-
	Moisture Content	20.9%	33.6%	%
	Saturation	78.7%	100.0%	%
	Change in Moisture Content	-	12.7%	%
	Overburden Mass	-	142.38	g
	Height of Water	2.44	-	cm
	Primary Swell	-	5.5%	%
	Ultimate Swell	-	5.9%	%

NOTES	4' - 6' Depth



Primary Swell (%)	5.5%
Slope of Primary Swelling	2.67% % per log cycle
Slope of Secondary Swelling	0.38% % per log cycle

Ultimate Swell (%)	5.9%
Time to Swell (hr)	3.73
Stress (psf)	505

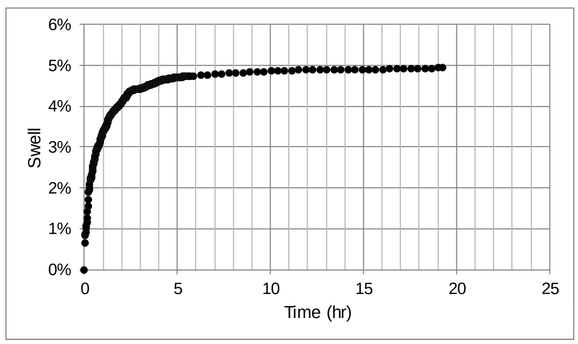
Date test conducted	8/1/2017
Centrifuge used	3
Cup Number	6
Conducted by	Karly

SOIL Information		
	Soil	US 87
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	32.19	gravity
	Initial Moisture Content	22.0%	20.9%	%
	Mass Soil Added	37.74	37.65	g
	Dry Unit Weight	15.13	15.50	kN/m3
	Height of Sample	1.000	0.990	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.029	cm
	Testing Height	0.972	1.021	cm
	Void Ratio, e	0.709	0.793	-
	Moisture Content	20.9%	33.7%	%
	Saturation	79.6%	100.0%	%
	Change in Moisture Content	-	12.8%	%
	Overburden Mass	-	141.87	g
	Height of Water	2.45	-	cm
	Primary Swell	-	4.5%	%
	Ultimate Swell	-	4.9%	%

NOTES	4' - 6' Depth



Primary Swell (%)	4.5%
Slope of Primary Swelling	2.45% % per log cycle
Slope of Secondary Swelling	0.35% % per log cycle

Ultimate Swell (%)	4.9%
Time to Swell (hr)	3.37
Stress (psf)	503

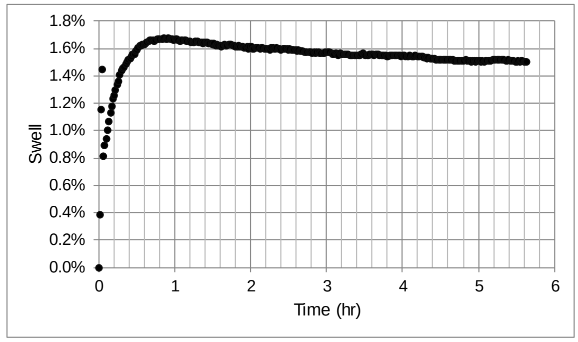
Date test conducted	8/17/2017
Centrifuge used	3
Cup Number	1
Conducted by	Karly

SOIL Information		
	Soil	4% HL
	Target Water Content	22%
	Water Content	21%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	25.88	gravity
	Initial Moisture Content	22.0%	20.7%	%
	Mass Soil Added	37.76	37.73	g
	Dry Unit Weight	15.15	15.34	kN/m3
	Height of Sample	1.000	0.989	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	-0.012	cm
	Testing Height	0.987	1.003	cm
	Void Ratio, e	0.727	0.756	-
	Moisture Content	20.7%	29.5%	%
	Saturation	76.7%	100.0%	%
	Change in Moisture Content	-	8.8%	%
	Overburden Mass	-	140.57	g
	Height of Water	2.44	-	cm
	Primary Swell	-	1.7%	%
	Ultimate Swell	-	1.7%	%

NOTES	US 87 4' - 6' Depth, 4% HL



Primary Swell (%)	1.7%	Ultimate Swell (%)	1.7%
Slope of Primary Swelling	0.84% % per log cycle	Time to Swell (hr)	0.77
Slope of Secondary Swelling	-0.26% % per log cycle	Stress (psf)	401

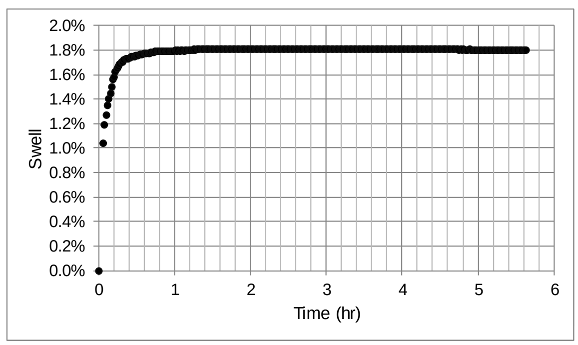
Date test conducted	8/17/2017
Centrifuge used	3
Cup Number	2
Conducted by	Karly

SOIL Information		
	Soil	4% HL
	Target Water Content	22%
	Water Content	20%
	Specific Gravity	2.70

TESTING SETUP Information	Property	Target	Actual	Unit
	G-Level	30.00	25.88	gravity
	Initial Moisture Content	22.0%	20.4%	%
	Mass Soil Added	37.72	37.67	g
	Dry Unit Weight	15.01	14.95	kN/m3
	Height of Sample	1.000	0.997	cm

TEST RESULTS Information	Property	Initial	Final	Unit
	Seating Height	-	1.400	cm
	Testing Height	1.013	1.031	cm
	Void Ratio, e	0.771	0.803	-
	Moisture Content	20.4%	29.4%	%
	Saturation	71.4%	98.7%	%
	Change in Moisture Content	-	9.0%	%
	Overburden Mass	-	141.25	g
	Height of Water	2.42	-	cm
	Primary Swell	-	1.7%	%
	Ultimate Swell	-	1.8%	%

NOTES	US 87 4' - 6' Depth, 4% HL



Primary Swell (%)	1.7%	Ultimate Swell (%)	1.8%
Slope of Primary Swelling	1.04% % per log cycle	Time to Swell (hr)	0.36
Slope of Secondary Swelling	-0.02% % per log cycle	Stress (psf)	403

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VITA

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This thesis was typed by the author.